MARCH 1985 VOL. 3, No. 3 $3.95

FOR IBM PERSONAL COMPUTER USERS

TECH JOURNAL

PC AND 3270-PC COMPATIBILITY

Adapting PC applications for the 3270

CONCURRENT PC-DOS

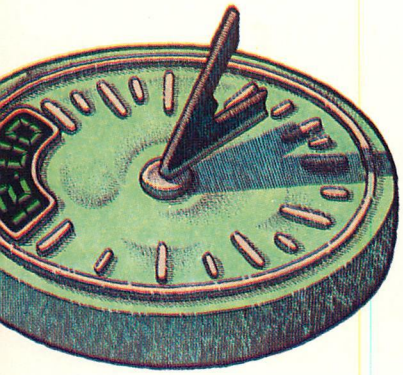
IBM PROFESSIONAL DEBUG FACILITY

CIRCUIT DESIGNS ON THE IBM PC

JRAM-2: BIG MEMORY FOR THE PC



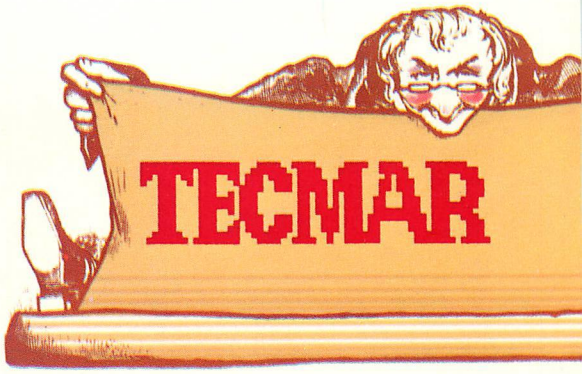
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Encode/Decode
Ensures the security of your files.



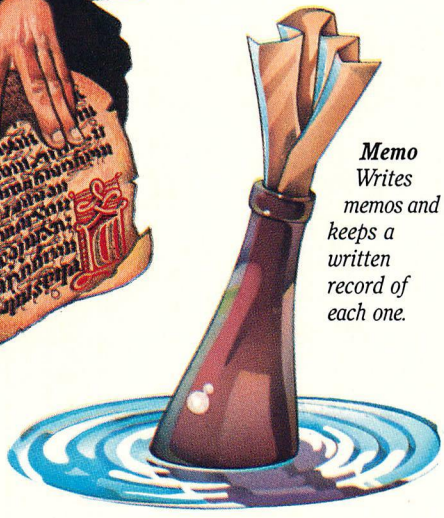


Appointment Reminder
Lets you know where to be and when.



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Uses your file to personalize your letters and make labels.

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Memo
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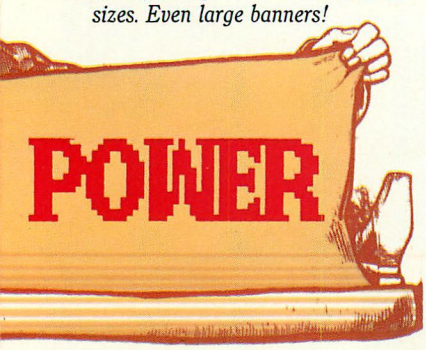
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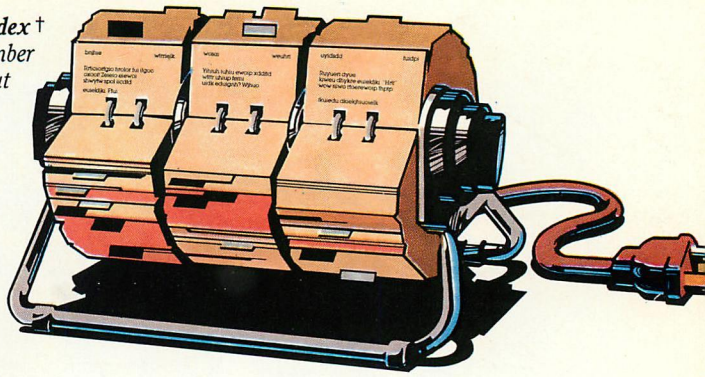
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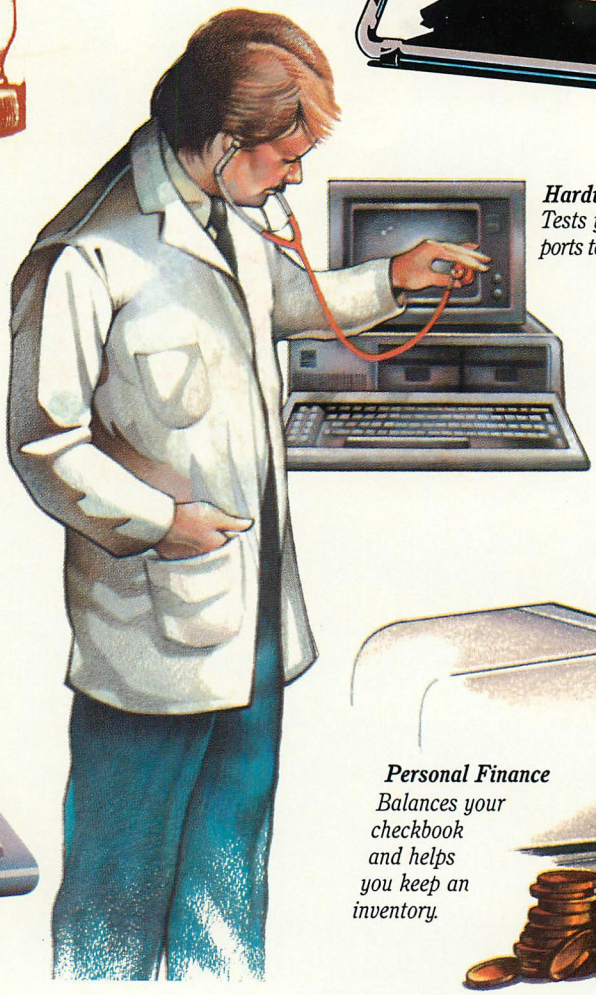
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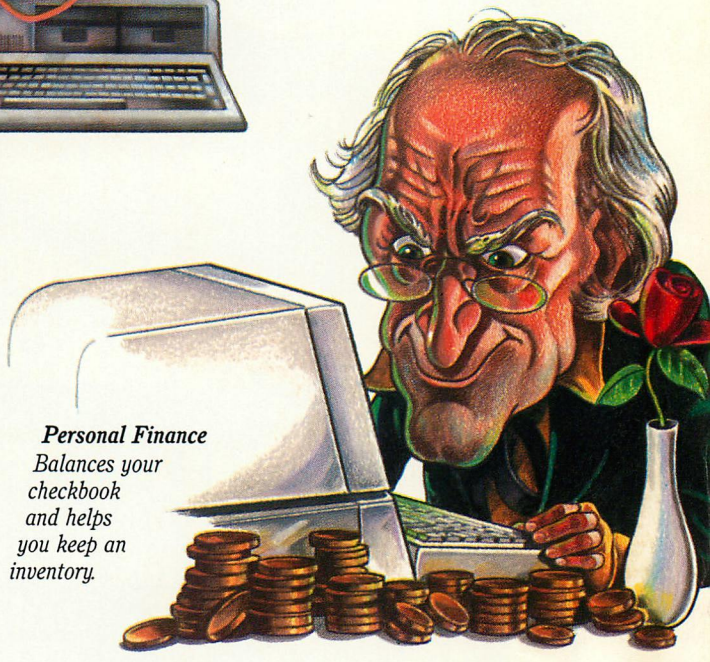






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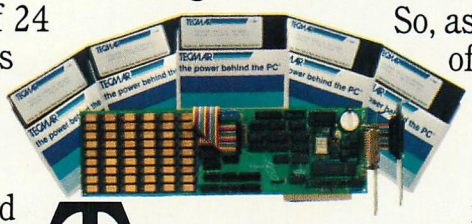
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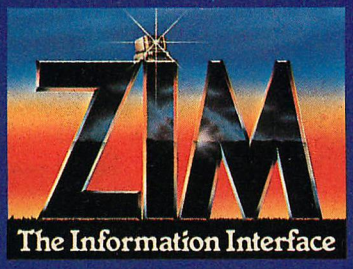
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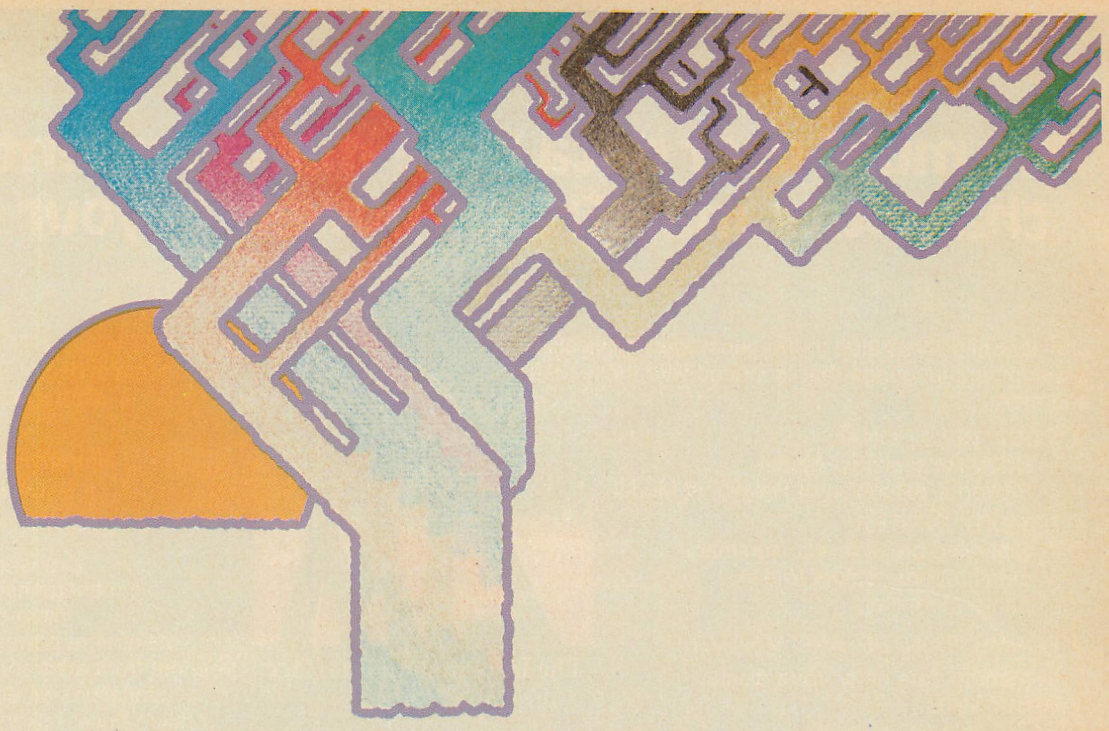
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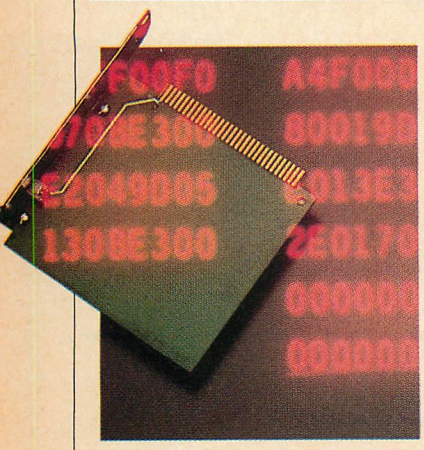
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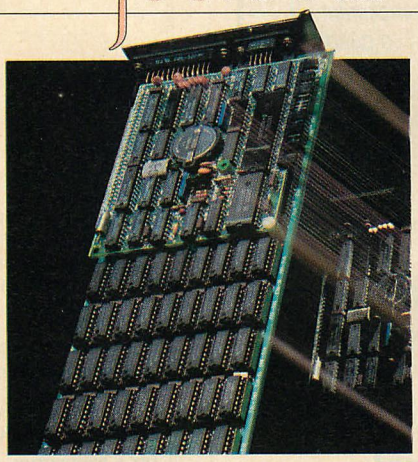
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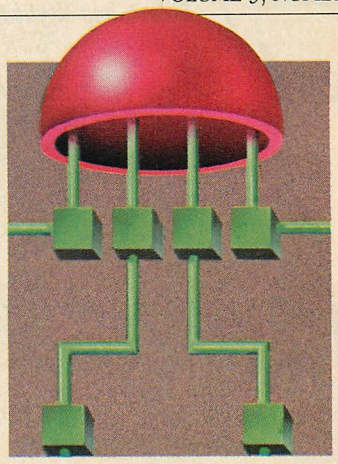
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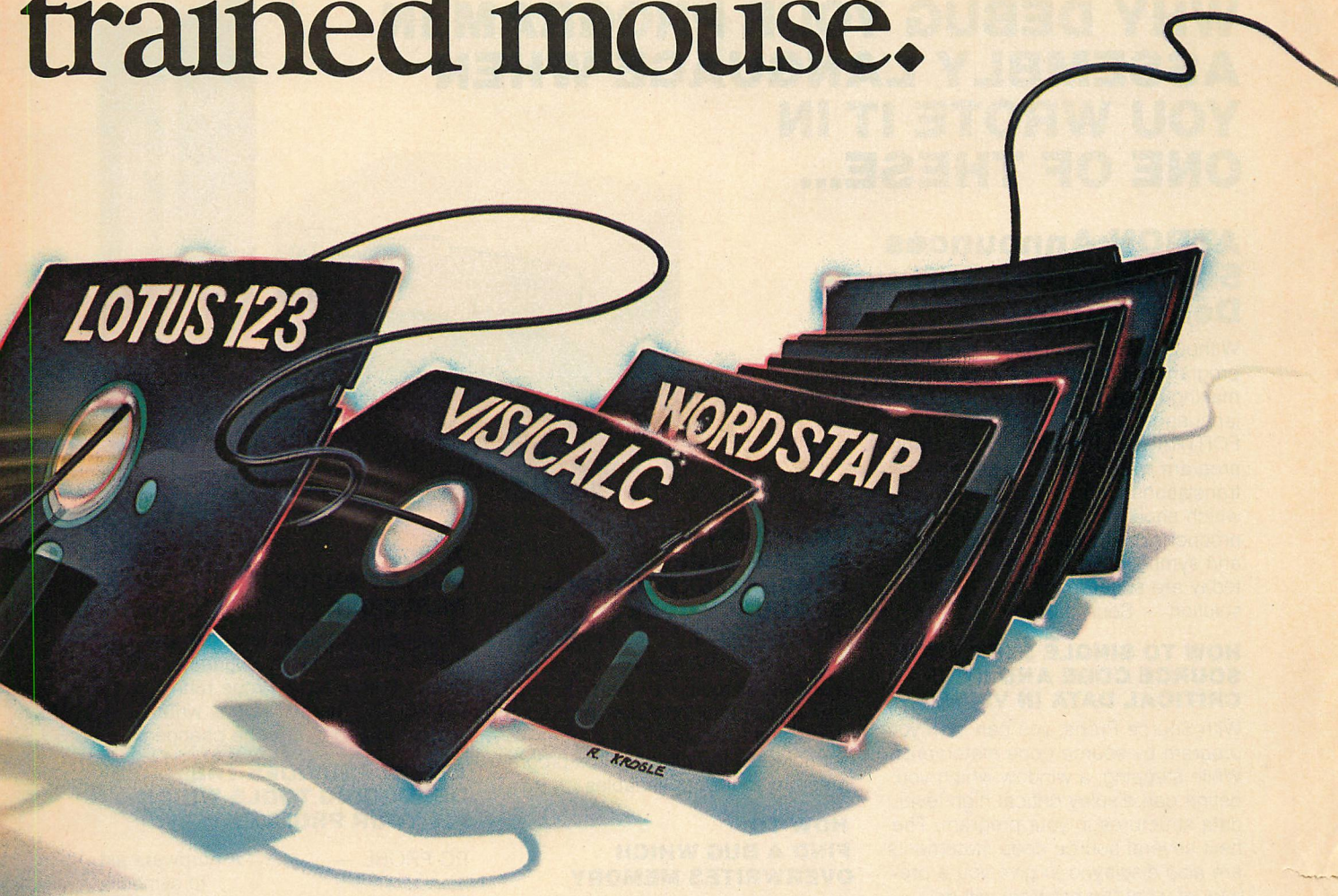


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WHY DEBUG YOUR PROGRAM IN ASSEMBLY LANGUAGE WHEN YOU WROTE IT IN ONE OF THESE...



ATRON Announces Source Level Software Debugging

Without source level debugging, the programmer must spend time mentally making translations between assembly language and the C, PASCAL, or FORTRAN source code in which the program was written. These tedious translations burn up valuable time which should be spent making critical product schedules. The low level hex and symbolic debuggers available today are superceded by ATRON'S solution — Source Probe.

HOW TO SINGLE STEP YOUR SOURCE CODE AND KEEP CRITICAL DATA IN VIEW

With Source Probe, you can step your program by source code statements. While stepping, a window which you define can display critical high level data structures in your program. The next several source code statements are also displayed to give you a preview of what the program will do

HOW TO DISPLAY DATA IN MEANINGFUL FORMATS

Why look at program data in hex when you defined it to be another data type in your program. Source Probe provides a formated print statement to make the display of your variables look like something you would recognize. You can specify data symbolically too.

FIND A BUG — FIX IT RIGHT NOW

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A SNAP SHOT OF REAL TIME PROGRAM EXECUTION — BY SOURCE CODE !

When Source Probe is running on ATRON'S PC PROBE hardware, the real time execution of the program is saved. You can then view your source code as it executed in real time — including all the changes the program made to your data variables.

HOW TO FIND A BUG WHICH OVERWRITES MEMORY

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Environmental Engineering

Which operating system will you choose?

Back in the good ol' days (circa 1981), we used to have fun arguing over which operating system for the IBM PC would gain market dominance. At the time, I was on the side of IBM DOS (aka MS-DOS) because of certain advantages I perceived the file system to offer over CP/M-86. There was an equally vocal group, of course, on the side of CP/M, and the dispute was vigorous and interesting for about a year. What happened at the end of that year is important for the lesson it teaches us now, and the problems soon to be faced by anyone who develops software for the IBM Personal Computer family.

What happened by late 1982 was that CP/M-86 had all but died. Even with considerable infusions of enhancement from Digital Research and the fact of its presence on the IBM price list, CP/M withered in the onslaught of applications written to exploit PC-DOS. My camp, the proponents of the IBM environment, had assumed this would happen because, after all, the operating system is called The *IBM* Personal Computer Disk Operating System. No other IBM O/S product carries the moniker directly; others simply carry the IBM label and nothing more.

What induced CP/M's fall from grace, besides the aforementioned horde of applications? IBM itself offered almost no products that operated in CP/M or another one of IBM's offerings, the UCSD p-System, thereby endorsing its own operating environment as the one of choice, and a de facto standard was born. So strong is this standard today that the manufacturers of clones strive to make their versions as compatible with IBM's as possible, and applications vendors write almost exclusively for the PC/MS-DOS world. To be completely accurate, IBM helped this standard along quite nicely by pricing DOS at $40, hundreds of dollars less than either CP/M or the p-System.

IBM's offering of three operating systems was presumed to result from a lack of confidence in its understanding of the market. That theory may have had some truth, but IBM was then preparing other applications for later release to run under DOS, not CP/M. IBM intended all along to make IBM DOS the standard environment.

Is that bad? I don't think so. It is critically important to have an effective, consistent operating environment to support the evolution of the product line over time. Applications, both from within IBM and from third-party sources, need to be available immediately for new machines, something that happens only when the new machine supports a compatible (or the same) version of the old operating system. IBM (or is it Microsoft?) has done this rather well to date. The fact that so many programs run on a new machine (the AT) with a new version of the operating system (DOS 3.0) testifies to clear thinking and careful planning.

Today, however, the waters muddy. If I were developing applications professionally, I might worry that questions about the future of environments on the IBM family would create the possibility that an application developed now might not be compatible enough for PC II or AT II or 3270-AT or whatever. The mud is coming from—if you haven't already guessed—IBM.

Consider the current situation. We have PC-DOS. We know about 3.1 and its support for the network. PC-XENIX is vaporware (announced but not delivered) as far as IBM is concerned, although Microsoft ships copies to independent systems vendors (ISVs); tenuous as it is, XENIX is anxiously awaited by certain market segments. We have been told about TopView, and there seems to be strong IBM support for it. The 3270-PC runs a special control program and offers a window environment; although the control program is largely transparent to DOS applications, some problems exist, and the windows are certainly not TopView (see "Programming for the 3270-PC" in this issue, page 174). We also have PC-Network and all that it implies for applications complexity and the need for consistent operating system support.

The aftermarket is busy, too. Microsoft has delayed Windows, which is expected this summer after nine months of rework. Alternate environments are available from other sources. Digital Research is given little operating system credibility (see "Concurrent PC-DOS," this issue, page 43), but others have interesting products, such as California Computer Products' Baby/34 and Baby/36 (Baby/34 is reviewed in a forthcoming issue of *PC Tech Journal*). UNIX implementations are available, as are add-on products for PC-DOS that provide multitasking capabilities.

So what is the developer to do? And what choices should a business make about the operating environment to be used on all those machines spread throughout the company? I don't know, because unlike the situation three years ago, the possibilities are all options apparently endorsed by IBM: PC-DOS, XENIX, TopView, the 3270-PC's control program, and even VM/PC for the AT/370. Worse, the options are actually layers: TopView runs over applications that can be running on DOS, and I expect it to run over XENIX, too. More bad news: the application written for DOS may not work in XENIX, unless by DOS version 11.0 we finally see Microsoft's promised bridge to the golden land of UNIX.

In short, we have IBM's list of environments, and a long one it is. What we do not have is a clear picture of where IBM is headed, exactly what it intends. Is TopView a smokescreen? Is XENIX the key? OS/370, God forbid? Or is it something entirely novel, something about which we have not yet heard? A Mac-like environment, perhaps?

Until a clearer picture emerges (and IBM may want the waters muddy if it is trying, as many suspect, to become

a major software player), we will just have to take our best guess.

My best guess at the moment is TopView, or something like it. By moving to such an environment, IBM opens several doors (or is it windows?) for the future and closes some other, nasty ones. In a windowed environment, especially on a higher resolution color display, a graphic, icon-based human interface becomes an option. In fact, instead of being the only option, it is simply the option for a particular window. A text and keyboard interface can be present in another window. The developer of such an application need not concern him/herself about the complexities of features and facilities that are not needed. In the nasty department, decisions about which operating system underlies the application may fade as TopView becomes the total environment, superceding PC-DOS or XENIX. TopView might be the operating environment of the future.

What makes me suspect TopView is the ultimate target for IBM is the 3270-PC Control Program, specifically the provision for multiple sessions with the host. IBM would not have decided on two sessions without good reason; the mainframe customer base must have wanted this feature. TopView should provide such a facility in a more generic way, and two sessions, obviously a contrived limit, vanishes when a window can operate any kind of session (host, PC, network, etc.).

One important consideration for the software developer or the system designer thinking toward the future is that the application under development must obey all operating environment rules. This could pose some severe marketing problems.

Lotus 1-2-3 is a prime example. The program obeys most DOS rules, but it also violates some BIOS rules—it has its own drivers for the display devices and avoids using any IBM BIOS or DOS facilities. The result is a very peppy performance. The user is not constrained to wait for the display, and most tasks happen in a flash. Now, try to consider 1-2-3 slipped in between layers of software, say DOS at the bottom and TopView above. Here, 1-2-3 *must* obey the rules or risk misbehavior when the user tries to run it in a small corner of the display.

But we also see the tough choice Lotus will have to face. Should 1-2-3 be left alone, to require full control of the machine and thus deliver its noted superior performance, or should it be adapted in such a way that the *i*'s are dotted and the *t*'s crossed, thus sacrificing one of its strengths for a greater, common good? As a 1-2-3 user, I would be pretty disappointed if the program suddenly became slower.

The performance question is a very important one. The speed with which the standard PC is operated through BIOS is not good. Programs that obey all the rules may have quick internal execution, but they are certainly perceived to run slowly as a result of inferior screen performance. The AT is better, but IBM cannot continue to overcome limitations in software design with a faster processor. Display speed is a psychological issue, and attention to it is of critical importance in windowed environments because the display is in a constant state of change.

What's my point? IBM must be careful not to engineer itself into a corner. Migration to a standard, consistent environment is good—but not at the expense of performance. If TopView is the ultimate goal, IBM will have to demonstrate spiffy display performance side-by-side with Mac or Lisa, or Apple's market share might begin to climb.



OUR STANDING INVITATION FOR YOUR COMMENTS

This is a very interesting time in the development of IBM PC family members. By some estimates, the IBM laptop—or at least a new PC—may be announced by the time you read this. As mentioned above, software confusion is mounting. IBM is suddenly and forcefully in the software business, and competitive pressures are rising.

I, and the other editors of *PC Tech Journal*, keep in regular touch with industry contacts, read the trade publications at great length, and travel extensively to trade shows, conferences, and vendors. With all that, it's still very hard to assess what our audience is up to: what products you are looking for, what problems you are experiencing, and what successes you are having. We extend our standing invitation for your comments on this magazine, your observations on the market, and your experiences with IBM computers.

Some topics are of special interest to us now as we plan our future editorial content. We want to share those topics with you, hoping you will share your views with us.

- More than 200 data management products are now on the market, but most attention in the press seems to be devoted to dBASE III. We plead guilty too, even as we are assigning our in-depth reviews of what we perceive to be the most important packages in this category. What are you using? Why? How are you doing? Problems? Wish you could start over, knowing what you know now?
- We would like to hear more about AT reliability experiences. IBM has said that no technical problem exists. CMI, manufacturer of the AT's fixed-disk drive, says the drive is good. In an informal poll I conducted of a very small sample, retailers say they have not been receiving any customer reports. A similar poll of ISVs reveals a failure rate of as much as 50 percent with the fixed-disk drive. A friend reports that his AT becomes stunned with regular frequency.
- It is clear that the XT/370 was a disappointment to many buyers who thought it might represent their salvation. The most oft quoted complaint: poor disk performance. The AT/370 should solve that problem, or at least alleviate it. Do you have an AT/370? If so, what do you think? How are you using it? Is it connected to a mainframe or are you building applications to stand alone?
- If you are developing software, what language are you using? What environment are you targeting? Have you had any problems?
- If you are communicating with mainframes, how are you doing it? Are you using an IBM 3270 approach, or is your 3270 hardware and software coming from some other vendor? Are you taking advantage of IBM's new lower cost options for connecting to mainframes with ASCII ports? And for what purpose are you using the links?
- Where are you headed with graphics? Is the announcement of the GSS software (especially the VDI) important to you? What do you think of the new subsystems from IBM?
- What's with UNIX? I ask this just as I am about to leave for UniForum 85, so I may have some ideas shortly. But what do you think? If you are not using UNIX now, do you think you will use it in the future?

We await your comments via US Mail, SOURCE STY682, or MCIMail at PCTECH.

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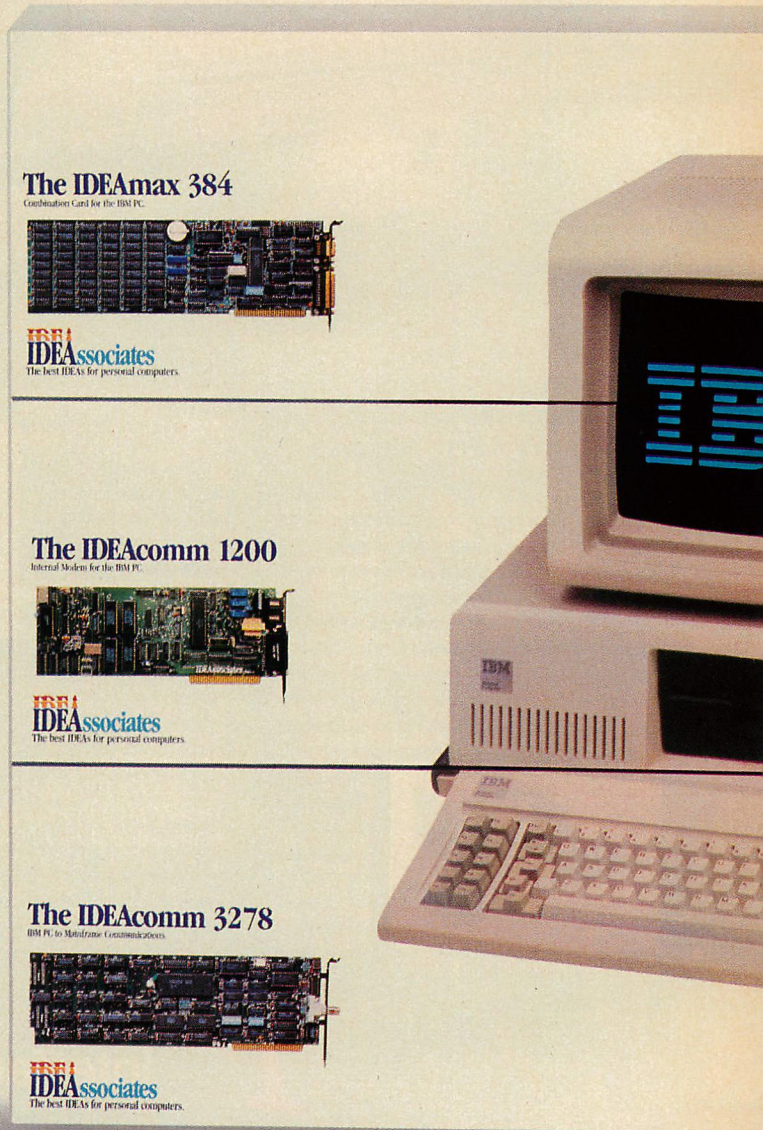
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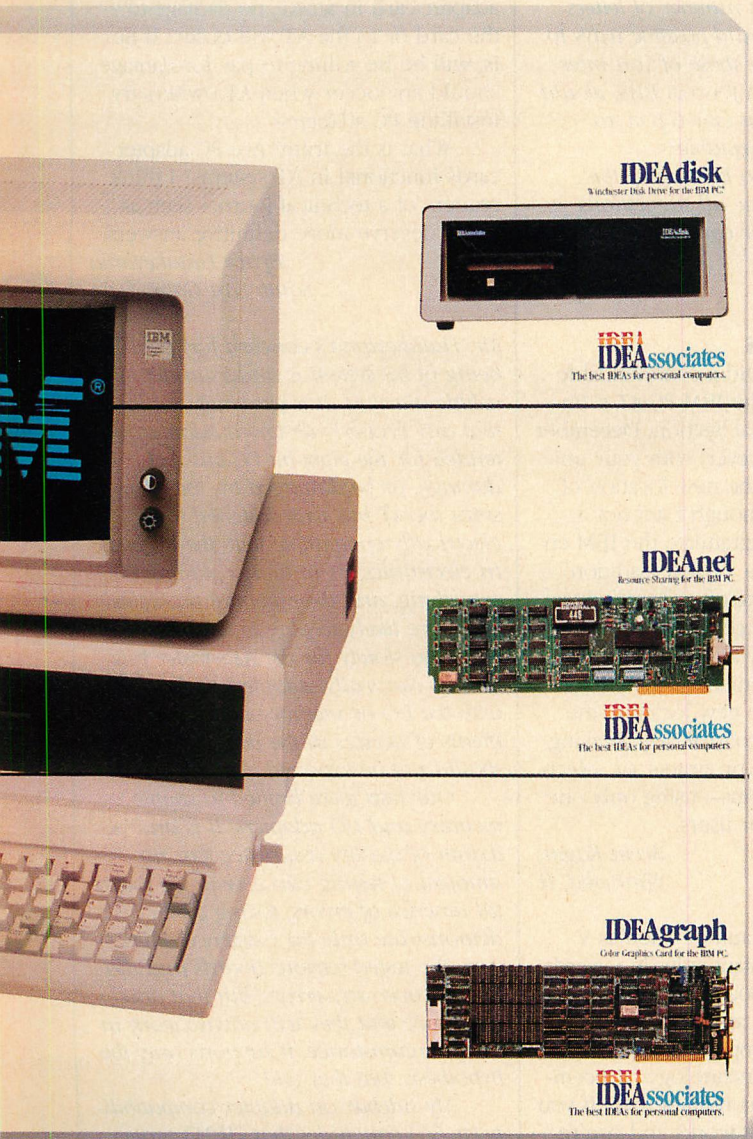
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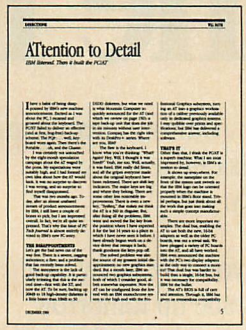
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PCAT TECHNICAL REVIEW

Analyzing the Advanced Technology

A technical review of IBM's latest, most powerful, and most advanced Personal Computer

THOMAS V. HOFFMANN


ATtention to Detail

DOWNLOADING LISTINGS

I would like to second Doug Sharp's letter ("Listing by Telephone," December 1984, p. 32) requesting a bulletin board system that would allow downloading of the magazine's programs.

Usually a person is not interested in *all* of the programs in a particular issue; he may have an intense interest in only one or two. These could be downloaded at a cost of probably around $5 in long-distance charges.

The ability to do this immediately after reading the article would be a great feature. I'm sure you are aware of the great popularity of IBM PC bulletin board systems today—one in Chicago is running four PCs networked together on four phone lines, and it is still difficult to get through.

Jack Wright
Hamilton Square, NJ

Downloading listings via telephone is a good idea and would be a great convenience. Although I enjoy reading most of the articles in *PC Tech Journal*, I generally want and can use only about four of the listings (for example, I do want to read your articles on APL, but I do not have an APL compiler and so cannot use the listings from those articles). For the few listings I want, it is not worthwhile to pay $20, wait four to six weeks for your listing diskette, and then get listings I cannot use.

If you do adopt the phone-line transmission, please do not drop the mail service. Occasionally you put out an issue that captures my interests (assembly language and C, for example) so much that I want and can use 90 percent of the listings. Also, there may be readers who collect *PC Tech Journal* in its entirety—in both printed and diskette form—for future reference.

Michael Yam
New York, NY

I would like to cast my vote in favor of the availability of your magazine's listing from a BBS or SOURCE SIG. For the occasional listing I would like to have, it just is not worth buying the complete listing diskette.

Anthony J. Leone, Jr.
Pittsford, NY

We have received a number of letters about our listings and possible ways to distribute them. For those of you interested in a PC Tech Journal *BBS, would off-hours operations (say 6 p.m. to 6 a.m. EST) be acceptable?*

We continue to investigate this matter and welcome all suggestions. Thank you for your comments.

—WF

PC/AT REACTIONS

I believe that you did a commendable job of presenting the IBM PC/AT ("Impressive AT," Special Section, December 1984). I differ, however, with your universal criticism of the new location of the Escape key. Although I am not a lover of IBM, I congratulate the IBM engineer who broke a 14-year tradition and moved the Escape key to its appropriate location. Conceptually, the Escape key is a control key and should reside in a position convenient to the cursor-control keys. In the new location, the operator has total control over viewing text, escaping from programs, or selecting items from menus—using only one hand. It is a plus for users.

Arvin Kagan
Winnetka, IL

I was disturbed by author Thomas V. Hoffmann's nonchalant attitude toward trying PC adapter boards in the PC/AT, as expressed in his article on the PC/AT's adapter compatibility ("Analyzing the Advanced Technology," December 1984, p. 40). His remark that "If you try something and it works and you're happy, that's fine. If it doesn't . . . " does not do your magazine justice, nor does it add to your credibility.

Has Mr. Hoffmann verified whether or not the electronics are compatible? The manner in which he wrote the article seemed to indicate that he has not (for example, he writes, "Eight-bit memory cards *seem* to work . . . "). Is Mr. Hoffmann saying that if I try a PC adapter card in an AT, no damage to the card or to the AT will occur? If he is, will he be willing to pay for damage should any occur when AT owners try installing PC adapters?

What is the truth? Are PC adapter cards functional in AT systems? I think readers of a technical journal such as yours deserve more definitive answers.

Bruce Hatakeyama
South San Gabriel, CA

Mr. Hatakeyama's concern for the well-being of his system is understandable, if a little alarmist. It is extremely unlikely that any properly designed adapter intended for the eight-bit PC bus will damage, or be damaged by, the AT bus, since the AT bus was designed to be electrically compatible with the PC bus. In electronics, as in humor, timing is everything, and the potential problems are more likely to plague adapters that react too slowly for the AT's faster bus timing. Naturally, adapters that conflict with the I/O or memory address assignments of devices in the base system should not be expected to work.

Our tests were limited to simple memory and I/O adapters. It is an axiom of quality assurance that no amount of testing can ever prove the total absence of errors; testing can demonstrate only the existence *of errors. We tested various boards and did not discover any errors; but that does not prove that they will always work in every circumstance; it supports only the hypothesis that they will.*

My sidebar on adapter compatibility (p. 56) concludes that "IBM's protestations of nonsupport seem a bit conservative, but you will not go wrong behaving as though they were true." I did

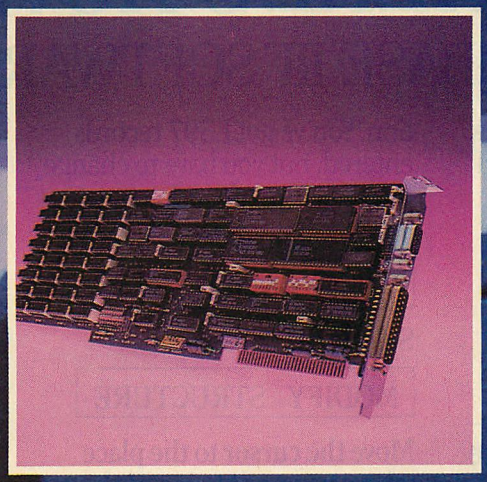
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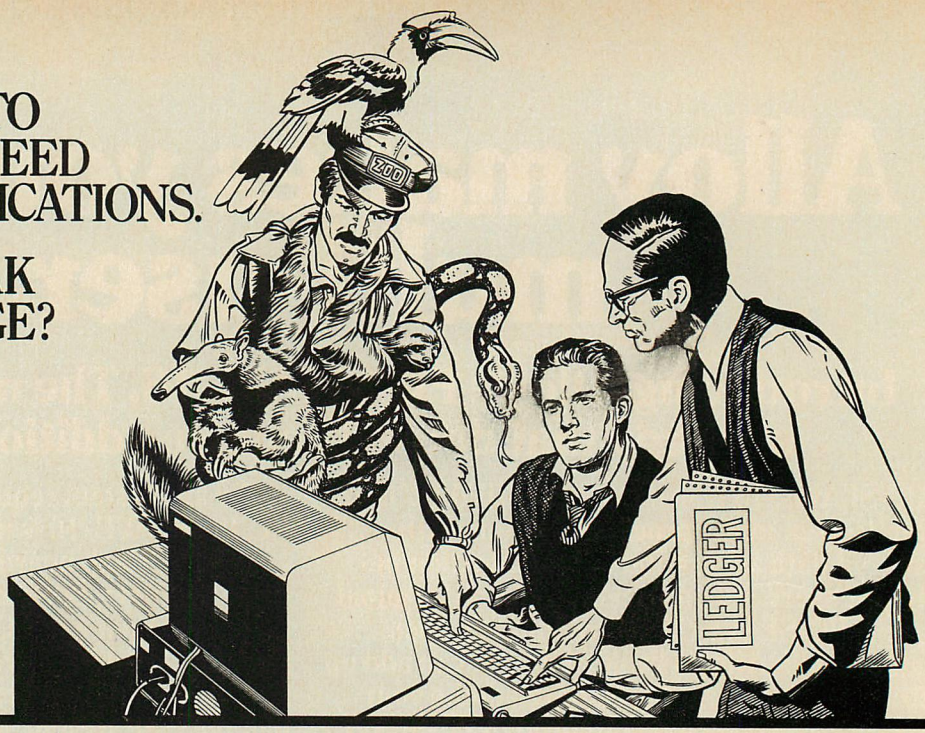
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Ctrl + N **Adds the new field.**

The new field will be inserted above the cursor position.

SEX ↵ ↵ 1 ↵

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Ctrl + W **ends your input.**

↵ confirms that you're satisfied with what you've done. Now, your customer is ready to identify his zebras as boys or girls using the program you created for him.

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not recommend sticking contraband adapters in your AT; if it makes you uncomfortable then don't do it.

—Thomas V. Hoffmann

DOS LIMITATION

I was interested to read your editorial ("ATtention to Detail," Will Fastie, December 1984, p. 5), which discussed IBM's PC/AT and mentioned DOS 3.0. The article gives the impression that DOS 3.0 overcomes the limitation in DOS 2.0 that makes programs unable to find ancillary files in subdirectories other than the current one.

This is a serious limitation; it severely restricts the user's ability to organize files (for example, it might be desirable to put all the files for users of the same PC in one subdirectory, all those relating to one customer in another, etc.). Users must keep multiple copies of programs and ancillary files in every subdirectory, keep every data file they use with a particular program in the same subdirectory as the program, copy files back and forth, or give up using subdirectories completely.

DOS 3.0 provides a mechanism whereby a program can be written or modified to overcome this limitation to some degree. Until and unless program vendors modify their existing programs to take advantage of the new DOS 3.0 facility, the programs will run exactly the same as under DOS 2.0.

Your readers should be made aware that our product, EasyPath, allows programs to find every file they need, in any subdirectory, under either DOS 2.0 or DOS 3.0. EasyPath does not require users to migrate from DOS 2.0 to 3.0, at the cost of additional memory.

Kevin Duffy
Polygon Software Corporation
New York, NY

SINGULAR ERROR

I am pleased with *PC Tech Journal* overall and was interested in your editorial on "The Hard (Or Is It Fixed?) Disk Revolution (Will Fastie, November 1984, p. 5). In your clause, "The disk (media) is usually sealed inside a chamber . . . ," the word *media* is incorrect, as it is plural. The correct term is *medium*, which is singular, as in "The recording medium used was. . . ." The "mass media" are plural because they include a number of mediums of communication, but the storage medium in a disk drive is singular.

I think an editor should be aware of such a distinction. (By the way, a similar distinction should be made between *datum* and *data*.)

William Lee Valentine
University City, MO

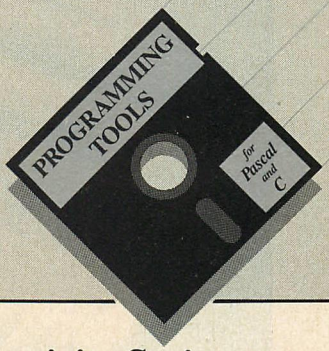
SEGMENT CHANGE CHECK-UP

In figure 1 of Tech Notebook 27 ("Patching a Bug in DOS 2.1," Don Awalt, November 1984, p. 71), the segment register at address 1522H is changed from the stack segment, SS, to the code segment, CS. Is this intended? Or was there an error in transcription between the IBM-supplied patch and that shown in the Tech Notebook?

Steve Itzkowitz
Canoga Park, CA

The segment-register change at address 1522H is intentional. Because DEBUG is a .COM file, the stack segment register and the code segment register actually point to the same address. IBM made the change only for consistency.

—Don Awalt



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Blaise Computing's Programmer Productivity series is also available in versions for the Pascal language.

BLAISE COMPUTING INC.
2034 Blake Street Berkeley, CA 94704
(415) 540-5441

CIRCLE NO. 114 ON READER SERVICE CARD

PC-AT®

The ultimate in PC performance.



Introducing Advantage! From AST.

The first and only multifunction board for your PC-AT, Advantage! lets you add millions of characters of memory capacity, two serial ports, a parallel port and a game port. All in a single expansion slot.

The Memory Advantage! Advantage! provides the extra memory you need to run sophisticated integrated software such as Framework,™ Lotus 1-2-3™ and Symphony.™ To operate multitasking programs such as IBM's TopView™ or multiuser operating systems such as XENIX.™ To handle larger amounts of data, faster. Or for RAM disks.

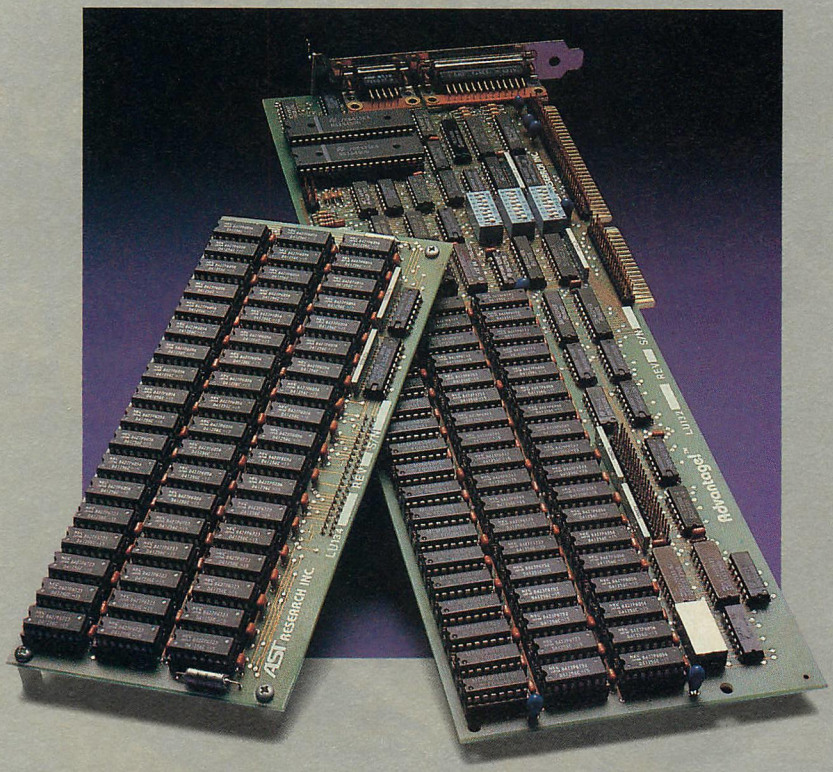
Our unique memory addressing technique rounds out your system board to 640K, and continues memory expansion at 1 Megabyte. You can add up to 3 Megabytes of parity checked user memory in a single slot using combinations of 64K or advanced 256K memory chips. And of course, Advantage! supports your AT's high performance bus and faster program processing speed.

The I/O Advantage! Connect printers, plotters, mice and joysticks. Add a modem to tap into CompuServe,® EasyLink,© Dow Jones® and other information networks. Or with the appropriate software, connect other terminals and create multiuser environments.

An AT compatible serial port and a parallel port are standard Advantage! features. With our optional second serial port you can attach even more peripherals,

Advantage!™

Ultimate performance enhanced.



while our optional game port lets you plug in joysticks and other cursor-control devices for business or just for fun.

The Future Advantage! Advantage! from AST means your future is open to expansion. When you use precious slot space to your best advantage, you save space for the state-of-the-art in your PC-AT's future.

The Quality Advantage! AST's reputation is built on quality products, quality support and quality service. Our complete documentation makes the Advantage! exceptionally easy to install and use, but if it's not enough we're always here to help.

The Advantage!—only from AST. It's the advantage your IBM PC-AT needs today. Call our Customer Information Center (714) 863-1333 Ext. 5249 for more information on the Advantage! multifunction board and other AST products, or the location of your nearest dealer.

AST Research, Inc., 2121 Alton Avenue, Irvine, CA 92714 TWX: 753699AST UR

FEATURES

Memory Expansion
- 128Kb to 3.0Mb in a single slot
- User Upgradeable with either 64K or 256K memory chips
- Split Memory Addressing rounds out AT's system memory to 640K and continues memory expansion at 1Mb

I/O Expansion
- Up to 2 Serial Ports (1 optional)
- Parallel Printer Port
- Optional Game Port

Advantage! Supports AT's Full Program Processing Speed

CIRCLE 101 ON READER SERVICE CARD

AST RESEARCH INC.

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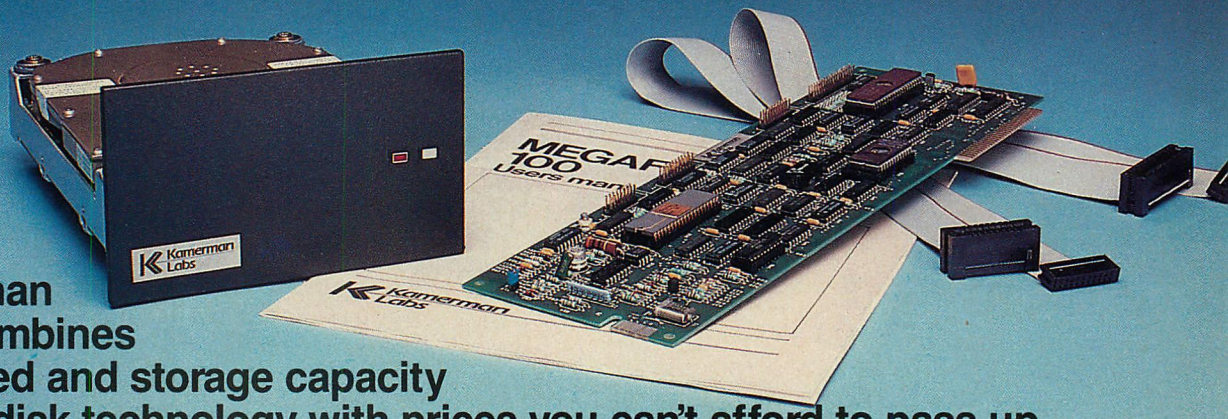
CIRCLE NO. 103 ON READER SERVICE CARD

FOR THE IBM® PC, IBM® XT, COMPAQ,™
CORONA,™ CORONA™ PORTABLE, LEADING EDGE,® EAGLE PC,® TAVA.™



10 Mbyte Hard Disk System

~~$895~~ $695



Kamerman Labs combines the speed and storage capacity of hard disk technology with prices you can't afford to pass up.

A dramatic leap in performance for your personal computer.

Even the smallest Kamerman Labs hard disk unit gives you 30 times the storage capacity of a typical floppy disk. Sophisticated business and professional data storage requirements can now be handled with ease.

Better yet, you can access data up to 10 times faster than with floppies. Spend more time working and less time waiting.

And it's easy to use. Kamerman Labs lets you boot directly off the hard disk, just like the IBM XT.

A complete backup solution.

Backup of hard disk data is a critical requirement in many microcomputer applications, so Kamerman Labs offers several reliable and cost-effective backup devices that are fully compatible with our hard disk units.

Lower prices than ever.

Because you deal directly with Kamerman Labs, we offer you remarkably low prices. Finally, you can realize the full benefits of hard disk technology without the excessive costs.

Tested and formatted.

All Kamerman Labs systems have been thoroughly tested and formatted before delivery.

Full warranty and technical support.

Kamerman Labs backs all its products with a full one-year warranty on both parts and labor. Plus you get prompt technical support through a toll-free hotline number.

To order, call toll-free 800-522-2237.

In Oregon, Hawaii and Alaska call **503-626-6877.**

IBM is a registered trademark of International Business Machines Corp.
Compaq is a trademark of Compaq Computer Corp.
Corona is a trademark of Corona Data Systems.

Leading Edge is a registered trademark of Leading Edge Products, Inc.
Eagle is a registered trademark of Eagle Computers.
TAVA is a trademark of TAVA Corporation.

All Kamerman Labs Units come in either internal or external configurations.

Kamerman Labs

8054 S.W. Nimbus, Bldg. 6, Beaverton, Or 97005
Phone 503-626-6877

CIRCLE NO. 237 ON READER SERVICE CARD

Paradise Modular Graphics Card

Graphics for monochrome and color displays



Although estimates of the number of IBM Personal Computers that have been sold vary wildly, a guess of 2 million is probably conservative. It is generally thought that between 40 and 50 percent are equipped with some kind of graphics display option, so it can be inferred that at least 50 percent, or about 1 million systems, are equipped with the IBM monochrome display subsystem, a display option that does not provide "all-points-addressable" graphics. Further, this ratio seems to hold for systems being purchased now.

A graphics capability is becoming more desirable as more programs offer useful graphics features. But the PC buyer is faced with difficult, and sometimes expensive, choices. If just the IBM Color/Graphics Adapter and an RGB monitor are purchased, the quality of displayed text is low and the price is more than $900 (IBM list). The prices of the popular monochrome replacement boards are reasonable, but the graphics do not conform to the IBM standard. Even the new IBM Enhanced Graphics Adapter (to be reviewed in the April 1984 issue of *PC Tech Journal*) is nonconforming: although it delivers a compatible monochrome display, a monochrome graphics standard is not yet supported by applications software. A lack of standards causes confusion regarding the graphics options for the IBM PC family.

Therefore, for a reasonably priced solution that delivers *compatible* graphics to the IBM Monochrome Display or equivalent, and for its growth and expansion potential, *PC Tech Journal* names the Paradise Modular Graphics Card as its March 1985 product of the month.

The Paradise card is not really a monochrome display adapter. It is actually a 100-percent IBM-compatible color graphics adapter with the additional capability to drive the IBM Monochrome Display. This capability, along with some clever software, makes the Paradise card such an ingenious and effective long-term purchase for the PC owner.

When connected to an IBM Monochrome Display, a provided program adjusts the operation of the board to deliver a graphics resolution of 640 pixels horizontally by 350 pixels vertically. This is narrower than the IBM Monochrome Adapter's 720 dots horizontally, but Paradise's program spreads the display so that it spans the full monochrome screen. The fewer pixels also means that Paradise cannot produce characters in IBM's 9-by-14 dot form-factor; instead, a character set built with 8-by-14 characters and strongly resembling the excellent character set of the IBM Enhanced Graphics Adapter is generated. A casual glance at the display is not sufficient to notice the IBM/Paradise difference.

The Modular Graphics Card can display any IBM color mode on a monochrome screen: the 16 colors become 16 shades of green for a very satisfying effect. Programs such as the Microsoft Flight Simulator and various painting programs run perfectly on the Paradise card and, although they are not as beautiful as they would be in color, they are certainly usable. Programs such as Lotus 1-2-3 and SuperCalc 3 can display graphs, using the IBM driver and the default driver respectively. As the Paradise ad says, all software for the color/graphics board runs on the Modular Graphics card, *unmodified*.

For a new PC buyer, the Paradise card and an IBM Monochrome Display represent an investment of $670, $145 more than a nongraphics all-IBM solution, but $254 less than an IBM color subsystem with its inferior text display. For an existing system, only the display adapter must be replaced for $395. Paradise also offers a piggyback board with a printer port for $95 (perhaps a little high) for those situations in which the port on the IBM monochrome card had been used.

The piggyback option is the second advantage of the Paradise solution. If system board slots are at a premium, up to two piggyback modules may be attached to the base display board. There are two types of modules, designated A and B (see box). An A module must be installed before a B module can be added. With currently available components, a Paradise card can support the display, 256KB of memory, a clock/calendar, and one port (parallel or serial).

PRODUCT NAME
Modular Graphics Card

COMPANY
Paradise Systems

ADDRESS
150 N. Hill Drive, #8
Brisbane, CA 94005

TELEPHONE
800/527-7977
800/822-2020; 415/468-6000 (in California)

PRICES
$395

A Modules
$95 (parallel port, serial port)

B Modules
$275 (clock and 256KB board—64KB installed)

The Paradise Modular Graphics Card is a good buy long-term. Because it is an IBM Color/Graphics adapter clone, it can also drive an RGB color display such as IBM's $680 model 5153, the IBM PC Color Display. This is one of the reasons the Paradise card is such a good value: later, the system can be upgraded to color simply by replacing the monitor. This flexibility increases the machine's resale value.

The Paradise board is not a perfect solution and it does have a few behavioral quirks. Some software packages see the board as a color adapter (because that is what it is) and thus switch to color modes instead of the preferred monochrome. But *PC Tech Journal*'s test of the unit went very well, and the company's claims for the product were verified. The shading for colors and display of text are excellent the operation of the display is flicker-free.

Hardware, software, and other developments for the IBM PC



Upgrade package

HARDWARE

Professional graphics and computer-aided-design tools are now available as an **Upgrade Package** from **Summit CAD Corporation.** These packages include comprehensive VHS video cassettes for training and self-tutorial sessions, AutoCAD Plus, a 32-bit ACCEL coprocessor, 256KB of RAM, a 640-by-400 pixel, 16-color display with high-performance graphics-display controller, a math coprocessor, and an optical mouse. Features include a true three-dimensional database, enhanced plotting utilities, instant hardware pan and zoom, and the capability to produce three-dimensional views and multiple windows. $5,995.
Summit CAD Corp., 5222 FM 1960, W102, Houston, TX 77069; 713/440-1468
CIRCLE 481 ON READER SERVICE CARD

Kensington Microware introduces the **Master Piece**, a multifunction accessory for the IBM PC, PC/XT, PC*jr*, and PC/AT. It provides a swivel for the PC's monitor and functions as a power control center for the computer system with five extra outlets and a master control switch. The Master Piece also protects the system from static charges and damaging power surges. $139.95.
Kensington Microware, 251 Park Avenue South, New York, NY 10010; 212/475-5200
CIRCLE 480 ON READER SERVICE CARD



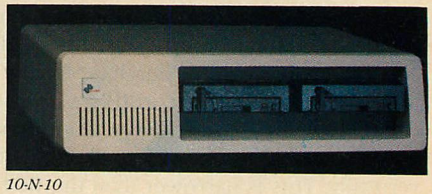
Master Piece

Kamerman Labs introduces **Masterflight**, a complete data storage system that incorporates a hard disk and back-up streamer tape in one 2½-inch-high unit. The external peripheral can be configured with a 10-, 20-, or 33MB hard disk and a 20-, 40-, or 60MB back-up tape. Five power-direction switches for the computer, monitor, printer, and two auxiliary units; a locking security key; and a surge protector are also included in the subsystem. Prices: $3,795 and up.
Kamerman Labs, 8054 W. Nimbus Avenue, Beaverton, OR 97005; 503/626-6877
CIRCLE 478 ON READER SERVICE CARD

Forte Data Systems has introduced the **3270PC** package, which gives the IBM PC, PC/XT, or PC/AT the functionality of an IBM 3270 PC workstation. PC users can obtain data from multiple host applications and view the data in concurrent sessions, while still maintaining the processing power of the PC. The package that provides the link between the IBM mainframe and the personal computer consists of the Forte PJ coaxial interface, an add-on board, and ancillary software. Up to seven interactive window sessions can be viewed on-screen: four active host sessions, one PC-DOS session, and two windows for notepads. Price: $1,495; users with the Forte PJ emulator already installed can upgrade their systems for $495.

Also from Forte Data Systems is **EComNet,** a host-based software environment for micro-to-mainframe communications. EComNet allows users to access host facilities and files through the same DOS commands that are used to call up locally stored data. EComNet functions as a PC-DOS bubble around the mainframe, implemented and controlled by a company's MIS department. The software can be installed on most IBM mainframes with an MVS 3.8, MVS/SP, or VM/SP operating system. PCs connect via coaxial cable through 3270-type control units. The PCs used with EComNet must be equipped with either of Forte's communications boards—Forte PJ or PC78-2—and must have at least 128KB of RAM. $8,000.
Forte Data Systems, 2205 Fortune Drive, San Jose, CA 95131; 408/945-9111
CIRCLE 475 ON READER SERVICE CARD

A dual removable 10MB hard-disk cartridge subsystem called **10-N-10** has been introduced by **XCOMP, Inc.** The subsystem allows the IBM PC and compatibles to have unlimited storage, back-up, and archive media, and it is supported by multiple operating systems. The hard-disk cartridges have a life span at least five times greater than other removable media. Each drive has an on-board microprocessor that enables the drive to write the servo information on the blank cartridge during the formatting process. Once formatted, the cartridge is interchangeable with all other 10-N-10 subsystems. $4,295.
XCOMP, Inc., 4223 Ponderosa Avenue, San Diego, CA 92123; 619/573-0077
CIRCLE 479 ON READER SERVICE CARD



10-N-10

Visage, Inc. has announced two IBM PC plug-compatible boards that let users build their IBM PCs into interactive video systems. The **V:Link 1500** and **V:Link 1550** plug-in boards, like Visage's V:Link 1000 (which provides an NTSC signal), include licenses for Visage's V:EXEC video disk virtual device interface for the IBM PC and its compatibles. Used with an analog RGB color monitor; a laser video disk player; and a keyboard, tablet, touch screen, or other



Analog Devices' MAS Software, used with the Series 120 I/O Cards

standard input device, the boards and interface provide interactive video with an RGB signal. The V:Link 1500 has an on-board graphics resolution capability of 256 by 192 pixels and can produce 16 colors. In addition, it has an input for 320-by-200 four-color graphics supplied from the IBM Color Graphics Adapter (or compatible product). The V:Link 1550 has the same features as the V:Link 1500, with the addition of resident 320-by-200 four-color graphics that can be overlaid on the video image simultaneously with or independently of the 256-by-192 graphics. Both the V:Link 1500 and 1550 can drive four player formats: serial, parallel, current pulse signal, and infrared. The boards require 256KB of memory (512KB for program development), DOS 2.0 or later, and one floppy disk. Prices: V:Link 1500, $1,850; V:Link 1550, $2,150.
Visage, Inc., 12 Michigan Drive, Natick, MA 01760; 617/655-1503

CIRCLE 471 ON READER SERVICE CARD

The **Professional 2400 Communicaton System** from **Novation, Inc.** is a full-duplex modem that can communicate at 2400 bps; in addition, it provides Bell 212A and 103A compatibility for 1200 and 0-300 bps calls. A new synchronous mode provides mainframe communications capabilities through compatibility with the many 327X/3770/3780 terminal-emulation packages now available. Other features include true dial-tone and busy-signal detection, automatic sequencing to alternate numbers when a number is busy, and security/password protection. $795.
Novation, Inc., 20409 Prairie Street, Chatsworth, CA 91311; 213/996-5060

CIRCLE 474 ON READER SERVICE CARD

A new high-speed semiconductor memory system for the IBM PC, PC/XT, and PC/AT has been announced by **THESYS Memory Products Corporation.** **FASTFILE** features rapid access time (less than 0.25 milliseconds) and a data rate of up to 1MB per second. The product is designed to work in local area networks and multiuser applications. Advanced caching and print-spooling software is included, as is a built-in uninterruptible power supply. 1.5 MB, $3,495.
THESYS Memory Products Corp., 7345 E. Acoma Drive, Scottsdale, AR 85260; 602/991-7356

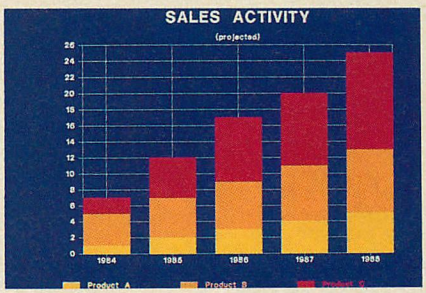
CIRCLE 472 ON READER SERVICE CARD

Analog Devices, Inc. has introduced the **Series 120** I/O cards, which supply integral measurement and control I/O for laboratory or industrial applications. These system configurations include automation functions such as real-world signal processing, man-machine interface, real-time analysis data acquisition, and supervisory control for use on the plant floor. The MIO120 card offers 32 channels of single-ended analog input, twice as much as is currently available on any other PC-compatible plug-in card. The AOT120 card, which supplies eight analog outputs, has the highest density of any analog-output card available. A menu-driven software package called Micro Automation System (MAS) is available for use with the cards; the package brings trending, sequencing, and Proportional Integral Derivative (PID) control capabilities to the IBM PC. Prices: MIO120 card, $1,495; AOT120 card, $1,450; MAS, $1,500.
Analog Devices, Inc., Three Technology Way, Norwood, MA 02062; 617/329-4700

CIRCLE 473 ON READER SERVICE CARD

A portable color-film recorder that reproduces computer-generated graphics into artist-quality 35mm color slides has been introduced by **Matrix Instruments, Inc.** The **Matrix PCR** interfaces with the IBM PC, PC/XT, PC/AT, XT/370, 3270 PC, and compatibles. It is compatible with all major graphics software packages, including Lotus 1-2-3. All slides are produced at a uniformly high resolution of 4 million pixels, regardless of the resolution of the terminal on which the graphics were created. Each pixel can assume any of more than 16 million colors. The unit is compatible with all conventional and instant slide films and can handle any new film type as it becomes available. $11,795.
Matrix Instruments, Inc., 1 Ramland Road, Orangeburg, NY 10962; 914/365-0190

CIRCLE 477 ON READER SERVICE CARD

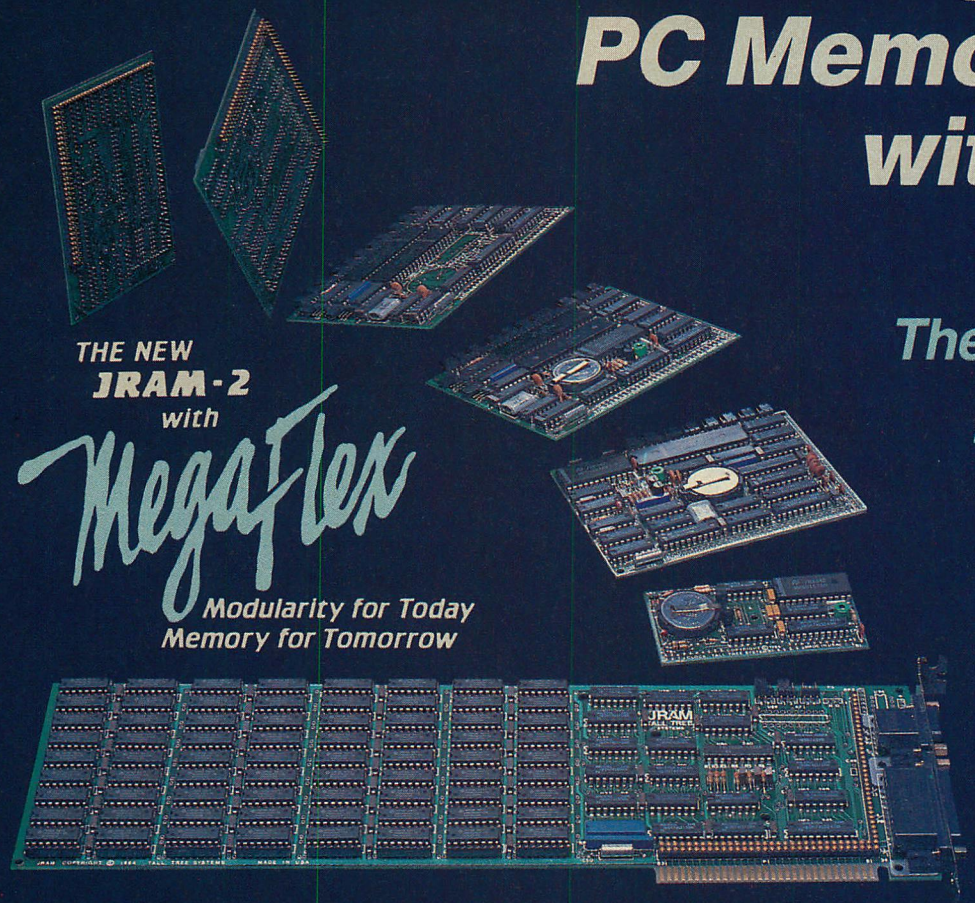


Matrix PCR

Attachmate Corporation's Attachmate-3270 consists of a fully integrated coax-interface board and control software that can be added to an IBM PC or compatible to allow it to function as a 3270 PC. Use of the Attachmate-3270 permits access to IBM 360/7, 30XX, or 4300 mainframes, as well as to existing 3270 control units. In addition, the Attachmate-3270 adds multiple micro-to-mainframe windows, allowing the user to run as many as four host sessions, two notepads, and one PC application concurrently. $1,195.
Attachmate Corp., 3241 118th S.E., Bellevue, WA 98005; 206/644-4010

CIRCLE 469 ON READER SERVICE CARD

Megaflex Your PC Memory Muscle with JRAM-2.



The first 2 megabyte multi-function memory board for IBM PC and all 100% compatibles...

Increase your computing power with Hardware and Software solutions for PC'S and compatibles...

- **EXPAND UP TO 2 MEGABYTES PER BOARD.** Add 256K chips one bank at a time as desired.
- **MODULAR I/O PORTS – EASY TO CHANGE AND UPGRADE.** The JRAM-2, with module, fits in a single slot.
- **FINEST CONNECTOR TECHNOLOGY – NO INTERNAL CABLES.** All add-on slots are easily accessible.
- **MOST POWERFUL SYSTEMS SOFTWARE – JETDRIVE AND JSPOOL.** Unparalleled power and increased computing speed.

PURCHASE ONLY THE FUNCTIONS YOU NEED.

CHANGE MODULES AS YOU WISH.

AVAILABLE NOW:

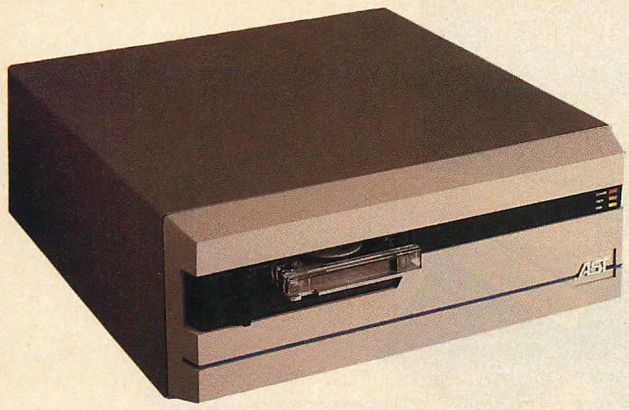
- JRAM-2 main memory board
- JRAM-2 with Clock-Calendar
- JRAM-2 with Clock-Calendar, Serial Port, and Parallel Port
- JRAM-2 with Clock-Calendar and two Serial Ports
- JRAM-2 with two Serial Ports
- JRAM-2 with diskette controller

All the memory capacity you'll ever need!

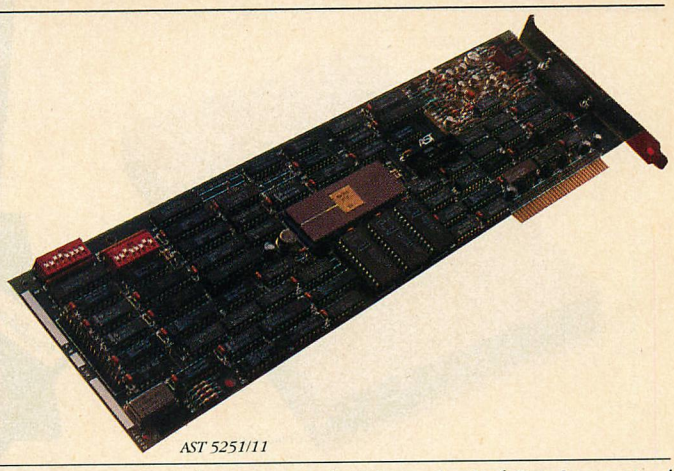
1032 Elwell Court,
Suite 124
Palo Alto, CA 94303
415/964-1980

TALL TREE SYSTEMS

CIRCLE NO. 197 ON READER SERVICE CARD



COLOSSUS



AST 5251/11

HYPERchannel, from Network Systems Corporation, is a high-speed networking system; it transmits data at 50 million bits per second. Among other capabilities, the product can connect equipment from various manufacturers and provide high-performance communications between processors. The HYPERchannel system uses a single multidrop coaxial cable data trunk to distribute equipment throughout a computing site; equipment is interfaced to the data trunk through HYPERchannel Network Adapters. Price: $38,500. Three-year leases are available for $300 per month.
Network Systems Corp., 7600 Boone Avenue North, Minneapolis, MN 55428; 612/425-2202

CIRCLE 468 ON READER SERVICE CARD

AST announces a hardware/software communications package that enables a standard PC, PC/XT, or PC/AT to emulate an IBM 5251 Model 11 display station for local interactive communications with an IBM System/34, /36, or /38 minicomputer. The **AST-5251/11** package also allows an inexpensive printer linked to the PC to emulate an IBM 5256 printer, without alteration to the host operating system. The local connect package consists of a microprocessor-based Twinax connection board and Model 11 emulation package. Standard hardware features include an 8-by-305 microprocessor, buffer management, one user-selectable DMA channel for XT and AT compatibility, and one selectable I/O interrupt channel. The communications program features single-keystroke switching from PC-DOS to System 34/36/38 and vice versa, as well as the ability to download applications files from the mini to the PC. $995.

Also announced is a **1200-baud, half-card modem** for the PC, PC/XT, PC/AT, and Portable called **REACH!** The card supports both half- and full-duplex communications and is bundled with Microstuf, Inc.'s Crosstalk XVI communications program. Features include Bell 212A and 103/113 modem compatibility, standard four-pin RJ11C phone jack, and a high signal-to-noise ratio for error-free transmission. Also included are call-progress monitoring, ringing/busy/no answer status report, and an on-board speaker. $549.

The first of a new line of disk subsystems for the PC family is also being introduced by **AST.** Called the **COLOSSUS,** the subsystem offers a 67MB Winchester disk drive with a 30-millisecond access time and a 60MB one-quarter inch streaming tape cartridge back-up housed in a stand-alone enclosure. Price: $7,499, including the host adapter.
AST Research, 2121 Alton Avenue, Irvine, CA 92714; 714/863-1333

CIRCLE 476 ON READER SERVICE CARD

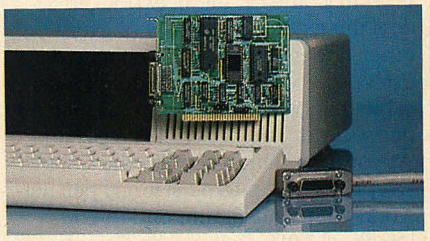
Great Lakes Computer Peripherals, Inc. has introduced **Stowaway II**, a removable, hard-disk cartridge subsystem that offers virtually unlimited storage capacity. Half-height Stowaway II uses an ANSI standard 5¼-inch metal oxide cartridge. Each cartridge provides 10MB of storage capacity. Stowaway II's design allows the disk platters to operate in an intensely controlled environment. Its high-speed operation, with a 94-millisecond average access time, allows fast, easy data retrieval and permits selective file back up.

Great Lakes offers Stowaway II in three configurations: first, as a module that fits inside any PC or compatible; second, it can operate inside one of the firm's Superior external hard-disk subsystems; and third, as a stand-alone device to operate in a single bay housing—the user can connect either one module or two. Great Lakes markets Stowaway II under an agreement with its developer, DMA Systems. $1,835.
Great Lakes Computer Peripherals, Inc., 2200 W. Higgins Road, Suite 245, Hoffman Estates, IL 60195; 312/884-7272

CIRCLE 466 ON READER SERVICE CARD

The **PC-488** from **Capital Equipment Corporation** is a second-generation IEEE-488 interface for the IBM PC, PC/XT, PC/AT, and compatible computers. The product is based in firmware rather than software; the firmware provides interpreted and compiled BASIC, Microsoft Pascal, DeSmet C (by CWARE), Microsoft C, Lattice C, and assembly language. There are no memory restrictions on programs or programming languages. Applications programs or compilers can use the entire 640KB memory address space. Three DMA modes are supported by the PC-488. An autoinitialize feature allows arrays of up to 64KB to be sent continuously in background mode without processor support. All command and data transfer routines are independent of DOS to provide transportability to other operating systems, such as UNIX. $395.
Capital Equipment Corp., 10 Evergreen Avenue, Burlington, MA 01803; 617/273-1818

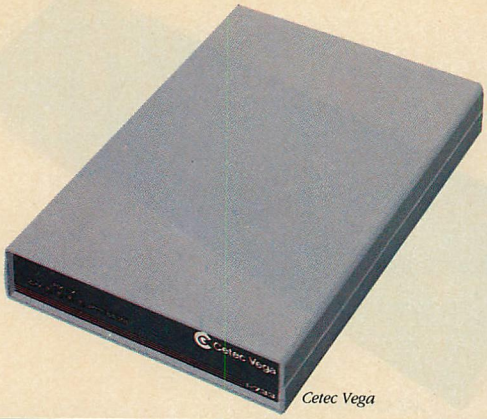
CIRCLE 470 ON READER SERVICE CARD



PC-488

Now available for the PC/AT is a **360KB compatible disk drive** from **PERSONAL COMPUTER PRODUCTS**. The drive is double-sided, double-density, with the bracket and clamp needed for installation; it mounts directly into the AT with no modifications. The drive features low power and quiet operation with the same type of closing mechanism as the high-capacity drive. Prices: black, $275; AT white, $290.
PERSONAL COMPUTER PRODUCTS, 1400 Coleman Avenue, Suite C-18, Santa Clara, CA 95050; 408/988-0164

CIRCLE 465 ON READER SERVICE CARD



Cetec Vega



FOXBASE II

Cetec Vega's new **I-733 DTMF/RS-232-C modem** converts received DTMF messages to ASCII format and converts ASCII messages from an RS-232 port to DTMF format. Incoming and outgoing messages are fully buffered to allow high-speed block data transfer. Prices: external modem, $395; internal, $275.
Cetec Vega, 9900 Baldwin Place, El Monte, CA 91731; 213/442-0782

CIRCLE 499 ON READER SERVICE CARD

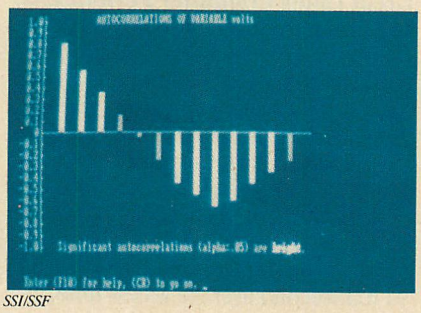
SOFTWARE

Centram Systems West, Inc. has introduced a **Transcendental-Networking System** (TOPS) that is totally operating-system independent, thus allowing computers of different makes and operating systems to participate in the network. TOPS translates the requests of each supported operating system into generic requests recognized by the TOPS software on the remote machines. Each machine on the network can access the text and data files of every other node. Machines are connected to each other with a low-cost telephone cable that operates at up to 0.8 megabits per second. The network is baseband, synchronous, and supports the CSMA/CD protocol. Up to 32 stations per network, with a maximum end-to-end length of 2,000 feet, can be linked.
Centram Systems West, Inc., 2372 Ellsworth Avenue, Berkeley, CA 94704; 415/644-8244

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Scientific Systems, Inc. has announced the **State Space Forecasting System (SSI/SSF)**, a multivariate statistical forecasting system for use in business, science, and finance. The package leads the user through a procedure to fit a state space statistical model to a historical time series of one or more endogenous or exogenous variables. The resulting model is then used to compute forecasts of the dependent variables. SSI/SSF is a unique combination of stochastic realization theory, statistical decision theory, state space models, canonical correlation analysis, and Kalman filtering. A full range of diagnostic statistics and graphical output is presented as each trial model is fitted to the data. An on-line help facility is provided. The package can be used in conjunction with other packages such as Lotus 1-2-3 and VisiOn. SSI/SSF runs on the IBM PC and PC/XT with at least 256KB. An 8087 is recommended. $495.
Scientific Systems, Inc., 54 Rindge Avenue Ext., Cambridge, MA 02140; 617/661-6364

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SSI/SSF

RUN/C is a C interpreter that conforms to standard Kernighan and Ritchie language standards. Developed by the **Age of Reason Company** and distributed by **Lifeboat Associates,** the program allows the user to edit and debug code interactively. Trace and profiler facilities aid in program debugging. Once the code has been entered, it can be compiled with any C compiler from within RUN/C. Minimum requirements are PC-DOS or MS-DOS version 2.0 or later and 256KB of memory. Price: $150, including a comprehensive manual.
Lifeboat Associates, 1651 Third Avenue, New York, NY 10128; 212/860-0330

CIRCLE 490 ON READER SERVICE CARD

A new relational database management system called **FoxBASE II** has been introduced by **Fox Software, Inc.** Written in C, FoxBASE II is a portable interpreter/compiler that is source-compatible with dBASE II, which allows users to run existing dBASE II programs without making any changes. In addition to all of dBASE II's features, FoxBASE II offers computational, file, and index operations that are three times faster than dBASE II's; database sorting that is up to 20 times faster than that of dBASE II; the ability to use 48 fields per record; and twice as many memory variables. Prices: development version, $395; runtime version, $695.
Fox Software, Inc., P.O. Box 269, 13330 Bishop Road, Bowling Green, OH 43402; 419/354-3981

CIRCLE 500 ON READER SERVICE CARD

The **EMUL85** and **EMULZ80** software emulators from **Microtec Research** allow any CP/M-80 and MP/M-80 .COM programs to be run on any computer operating under MS-DOS, PC-DOS, or CP/M-86 without the purchase of a CP/M license. Two versions are available: one for the 8080/85 processor and one for the Z80 processor. The emulators map CP/M files into the files of the host computer. The applications programs operate just as if they were being run on standard 8080/85 or Z80-based machines. All BDOS and BIOS calls are implemented under CP/M-86; under MS-DOS all BIOS calls except several that handle direct disk access are implemented. The emulators can be customized for specific applications. Prices: EMUL85, $95; EMULZ80, $125.
Microtec Research, 3930 Freedom Circle, Suite 101, Santa Clara, CA 95054; 408/733-2919

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Available for IBM PC

What C did for Programming
Mark Williams has done for C Programming

The C Programming System from Mark Williams

MWC86 gets your C programs running faster and uses less memory space than any other compiler on the market. Then *csd*, Mark Williams' revolutionary C Source Debugger, helps you debug faster. That's The C Programming System from Mark Williams Company.

MWC86

MWC86 is the most highly optimized C compiler available anywhere for the DOS and 8086 environment. The benchmarks prove it! They show MWC86 is unmatched in speed and code density.

MWC86 supports large and small models of compilation, the 8087 math coprocessor and DOS 2.0 pathnames. The compiler features common code elimination, peephole optimization and register variables. It includes the most complete libraries. Unlike its competition, MWC86 supports the full C language including recent extensions such as the Berkeley structure rules, voids, enumerated data types, UNIX* I/O calls and structure assignments.

Quality is why Intel, DEC and Wang chose to distribute MWC86. These industry leaders looked and compared and found Mark Williams to be best.

User Friendly

MWC86 is the easiest to use of all compilers. One command runs all phases from pre-processor to assembler and linker. MWC86 eliminates the need to search for error messages in the back of a manual. All error messages appear on the screen in English.

A recent review of MWC86 in *PC World*, June, 1984, summed it up:

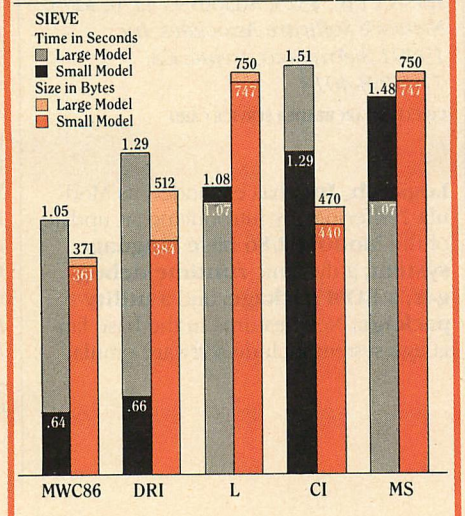
"Of all the compilers reviewed, MWC86 would be my first choice for product development. It compiles quickly, produces superior error messages, and generates quick, compact object code. The library is small and fast and closely follows the industry standard for C libraries."

csd C Source Debugger

Mark Williams was not content to write the best C compiler on the market. To advance the state of the art in software development, Mark Williams wrote *csd*.

csd C Source Debugger serves as a microscope on the program. Any C expression can be entered and evaluated. With *csd* a programmer can set tracepoints on variables and expressions with full history capability and can single step a program to find bugs. The debugger does not affect either code size or execution time. *csd* features online help instructions; the ability to walk through the stack; the debugging of graphics programs without disturbing the program under test; and evaluation, source, program and history windows.

csd eases the most difficult part of development — debugging. Because *csd* debugs in C, not assembler, a programmer no longer has to rely on old-fashioned assembler tools, but can work as if using a C interpreter — in real time.



The C Programming System from Mark Williams now supports the following libraries:

Library	Company
Windows for C	Creative Solutions
Halo	Media Cybernetics
PHACT	PHACT Associates
The Greenleaf Functions	Greenleaf Software
Btrieve	SoftCraft

The C Programming System from Mark Williams

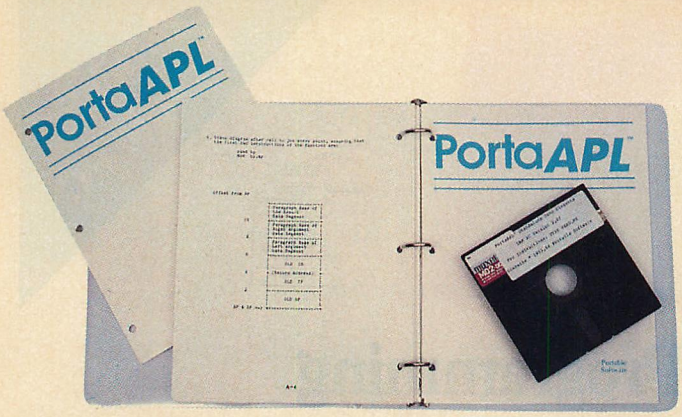
The C Programming System from Mark Williams delivers not only the best C compiler for the 8086 but also the only C source level debugger. That's why it does for C programming what C did for programming. The Mark Williams C Programming System gives the programmer the MWC86 C compiler and the *csd* C Source Debugger for only $495. Order today by calling 1-800-MWC-1700. Major credit cards accepted.

Technical support for The Mark Williams C Programming System is provided free of charge by the team that developed it.

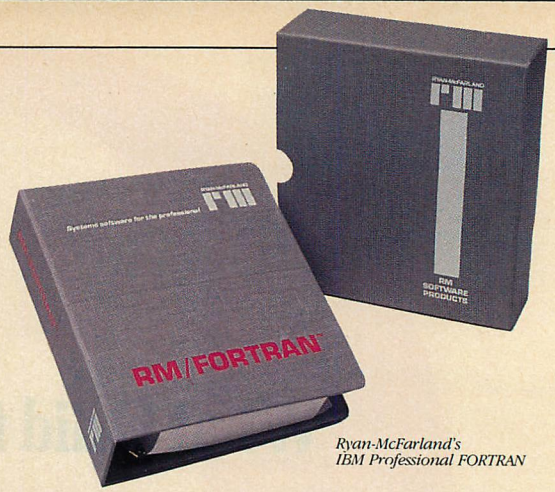
Mark Williams Company
1430 W. Wrightwood Ave.
Chicago, IL 60614

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*Unix is a Trademark of Bell Laboratories.



PortaAPL



Ryan-McFarland's IBM Professional FORTRAN

A complete implementation of standard APL, **PortaAPL,** has been released by **Portable Software.** The interpreter, written in C, contains all of the primitive APL functions, system functions, and system commands in the IBM/ACM APL standard, with the exception of shared variables. A full-screen editor, access to machine language functions, and several extensions are also included. The implementation is identical for each machine type upon which it can be used—the IBM PC, Sanyo PC, DEC VAX, and Motorola—so programs can be easily ported from one machine to the other. Two system commands allow workspaces to be transferred between the dissimilar computers. PC version, $195; source and OEM licenses are available.
Portable Software, 60 Aberdeen Avenue, Cambridge, MA 02138; 617/547-2918

CIRCLE 494 ON READER SERVICE CARD

Dighera Data Services has announced the release of a complete, ready-to-run **electronic bulletin board service** for the PC, PC/XT, PC/AT, and compatibles. The package contains the bulletin board software, system-maintenance programs, and a comprehensive collection of more than 200 public-domain programs and files. The software supports messages, file transfer, an extensive security system, and remote host-computer operation via the DOS CTTY command. The BASIC source code is included, so the program can be tailored to specific applications. Minimum requirements are 256KB, two double-sided, double-density diskette drives, and a modem. $59.95.
Dighera Data Services, P.O. Box 12100, Santa Ana, CA 92712; 714/842-6348

CIRCLE 489 ON READER SERVICE CARD

SoftStyle, Inc. now offers **Printworks,** a software facility that provides easy, complete control over more than 30 models of dot matrix printers for the IBM PC. It allows menu selection of printing modes and characteristics and includes such advanced features as special fonts (foreign language, math, and graphics), a custom font editor, and sideways printing. Among the controllable attributes are pitch, mode, face, font, and format. A quiet-mode setting reduces ambient noise by forcing the printer to operate at half speed. $69.95.
SoftStyle, Inc., 7192 Kalanianaole Highway, Suite 205, Honolulu, HI 96925; 808/396-6368

CIRCLE 483 ON READER SERVICE CARD

Network Software Associates, Inc. announces the immediate availability of its micro-to-mainframe communications-emulator family for the PC/AT. Products now available are **AdaptSNA 3270, AdAptSNA Printer, AdaptSNA RJE, and AdaptBSC 3270.** The first three products emulate IBM terminal products in a systems-network architecture environment, and the fourth emulates a 3270 terminal in a bisynchronous environment. These emulators work in conjunction with IBM's SDLC or Bisynch Adapter cards for the PC, so users do not have to purchase special adapters for the PC/AT. The products emulate a wide range of IBM communications products, including the 3274, 3278, 3279, 3286, 3287, 3770, and 8100. Prices: AdaptSNA 3270 with AdaptSNA Printer, $325; AdaptSNA RJE, $325; AdaptBSC 3270, $275.
Network Software Associates, Inc., 19491 Sierra Soto, Irvine, CA; 714/768-4013

CIRCLE 482 ON READER SERVICE CARD

Logitech, Inc. has expanded its Modula-2 offerings by introducing an update of the **Modula-2/86 base language system,** a dynamic **runtime debugger,** a **ROM package,** and a **utility package.** New features in the base language system include software emulation for real data-type operations, 8087 support, and the library modules CLOCK and RealConversions. Speed of the compiler, linker, and applications programs has been improved by as much as 50 percent. The runtime debugger features unlimited breakpoints, execution trace by statement or procedure calls, symbolic examination and modification of program variables, and debugging of programs with overlays or multiple processes. The ROM package allows programs to be burned into ROM or EPROM chips. The utilities package is an extension of the standard library and contains modules for decimals for calculations with long integers and a decoder that provides assembly language listings of Modula-2 programs. Prices: update of base language system, $75 (for registered users); ROM package, $350; Utilities package, $75.
Logitech, Inc., 805 Veterans Blvd., Redwood City, CA 94063; 415/365-9852

CIRCLE 487 ON READER SERVICE CARD

Ryan-McFarland Corporation has delivered **IBM Professional FORTRAN**, a GSA-certified, error-free, full FORTRAN-77 for the IBM PC, PC/XT, and PC/AT. In addition to being a full-level FORTRAN-77, it is designed to support existing mainframe FORTRAN applications. Features include object-code optimization, an interactive symbolic debugger, and support for arrays of unlimited size. The implementation has both 8087 and 80287 support. Extensions include symbolic names of up to 31 characters, IRTF, binary pattern and bit processing functions, Hollerith and hexadecimal constants, and additional data types found in mainframe applications, such as COMPLEX*8. $595.
Ryan-McFarland Corp., 609 Deep Valley Drive, Rolling Hills Estates, CA 90274; 213/541-4828

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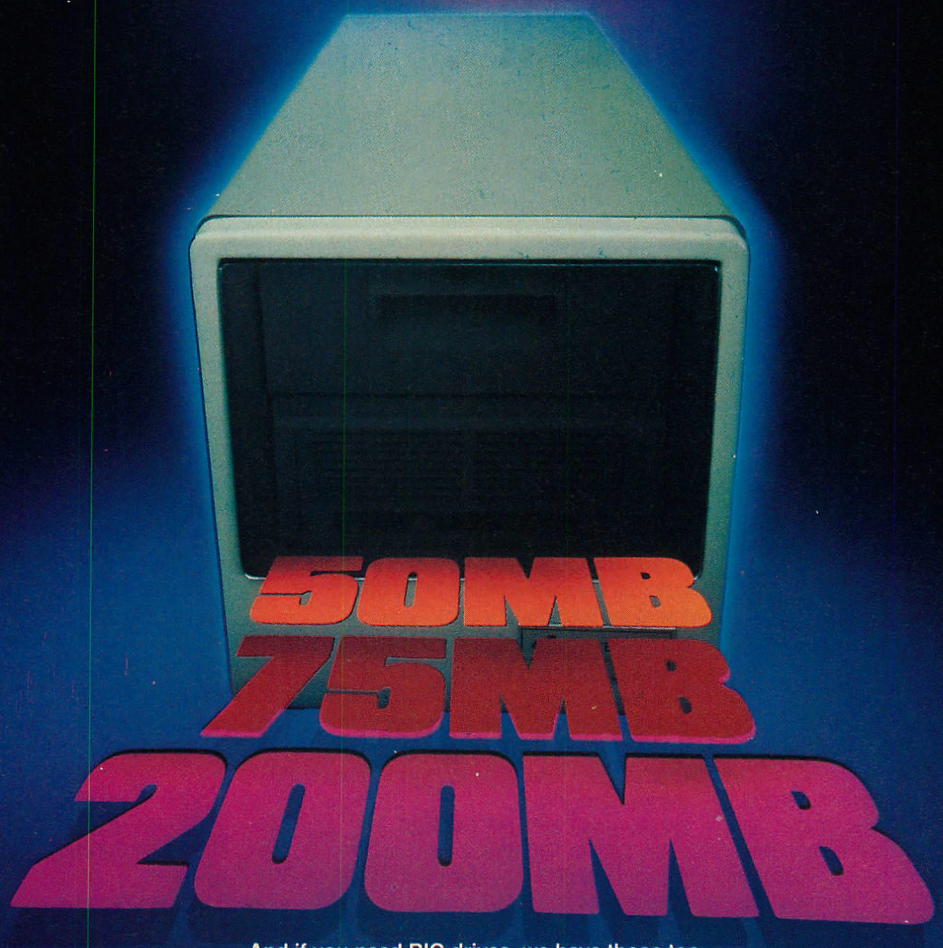
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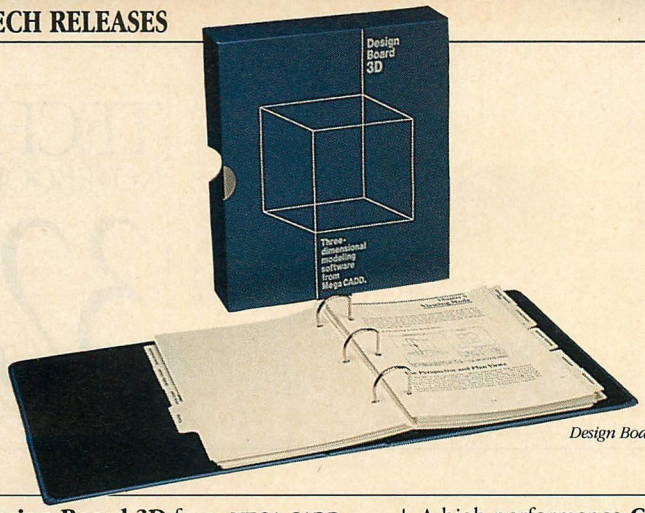
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And if you need BIG drives, we have those too.

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Design Board 3D



Plain English

Design Board 3D from **MEGA CADD, Inc.** addresses front-end, three-dimensional conceptual design for architectural, engineering, and design applications. Users can create, modify, and plot three-dimensional designs and can work with unlimited shapes, including domes, ellipses, spheres, and free-form curved surfaces. As many as four views of a design can be viewed simultaneously. Design Board 3D also features automatic hidden line removal, so designs can be seen without distracting lines. $750.
MEGA CADD, Inc., 401 Second Avenue S. Seattle, WA 98104; 206/623-6245
CIRCLE 498 ON READER SERVICE CARD

Lattice, Inc. has announced two new products. Its **Text Management Utility** is for the PC, PC/XT, PC/AT and PC compatibles running under PC-DOS. Four utilities provide the user with extensive text-handling abilities: GREP searches files for patterns and displays the line and number of the located text; DIFF compares two files and provides a description of any changes required to transform one file into the other; WC reads a file and reports the number of characters, words, and lines it contains and computes a unique checksum for the text file that is independent of the character set of the machine on which it is running; ED, a line editor similar to the UNIX ED editor, is also included. Price: $120 ($240 with source code).

C-SPRITE is a source code debugger for programs written in Lattice C or assembly language. It can be used with .COM or .EXE files and has powerful macro facilities. Other advanced facilities include help screens, conditional commands, breakpoints, and support for PLINK overlays. To facilitate testing a program that is heavily screen-oriented, a serial terminal can be connected to the main system unit. MS-DOS or PC-DOS version 2.0 or later and at least 128KB of memory is required. $175.
Lattice, Inc., P.O. Box 3072, Glen Ellyn, IL 60138; 312/858-7950
CIRCLE 491 ON READER SERVICE CARD

A high-performance **COBOL Level II** compiler has been announced by **Digital Research, Inc.** The compiler has been certified by the Federal Software Testing Center to meet the full ANSI specifications for high-level compilers, and it has no runtime library licensing fee. Included in the package are two programming utilities: Display Manager, used for screen display creation, and Access Manager, for data record maintenance. Level II COBOL supports PC-DOS and MS-DOS operating systems and generates native code for the 8086/88, 80186/188 and 80286/288 families of microprocessors. The compiler was developed jointly by Digital Research and Micro Focus Ltd. $700.
Digital Research, Inc., Box DRI, Monterey, CA 93942; 408/649-3896
CIRCLE 492 ON READER SERVICE CARD

Plain English, an extensible computer language that uses English commands, is now available from **Common Language Systems, Inc.** It uses a building-block approach, similar to FORTH, that allows the programmer to create a unique, customized programming vocabulary. The interpreted language supports color, sound, and graphics, and includes four accounting modules built with the system. A reference and tutorial manual are supplied, and the package can be used on any MS-DOS-based operating system. $595.
Common Language Systems, Inc., 100 E. Sybelia Avenue, Maitland, FL 32751; 305/628-5973
CIRCLE 495 ON READER SERVICE CARD

A fourth-generation programming language called **cENGLISH**, with syntax similar to dBASE II, has been released by **CLINE, Inc.** The high-level interface to C allows programmers to generate C programs without having to learn the intricacies of the C language. The compiler has an interface that translates cENGLISH into C source code, using the host C compiler to output machine code. Applications developed on one system can be ported easily to another without modification. cENGLISH supports multidimensional arrays, procedure function calls, and a uniform user interface to several popular database managers. Price: $795.
CLINE, Inc., 20 W. Ontario, Chicago, IL 60610-3809; 312/944-4510
CIRCLE 497 ON READER SERVICE CARD

Protype, a memory-resident printer facility, has been announced by **Photon Software.** The program allows the user instant access to any make or model printer and offers such features as instant font selection, an on-screen file of user-configured office forms, a line-by-line print option allowing memory typewriter-like functions, and a composition mode for printing memos and letters. Its unique font selection menu enables a word processor to be totally printer-independent. Price $119.95.
Photon Software, 636 120th Avenue, N.E., Bellevue, WA 98005; 206/451-8272
CIRCLE 484 ON READER SERVICE CARD

Blaise Computing, Inc. has announced the **Asynch Manager,** which provides system developers with interrupt-driven and polling control over communications ports from within their high-level language programs. Possible applications include file transfer between computers, real-time data acquisition, and printer/plotter control. The program is available with Pascal and C language interfaces for major development compilers. Prices: $175, including a manual and source code for one language; $50 for the second language interface.
Blaise Computing, Inc., 2034 Blake Street, Berkeley, CA 94704; 415/540-5441
CIRCLE 485 ON READER SERVICE CARD

More Ports

Using more than two serial ports on the PC

TECH NOTEBOOK 32

JACK WRIGHT

In the IBM PC, both DOS and BASIC support a maximum of two serial ports (COM1 and COM2). The main reason for this situation is that each port requires its own interrupt line, and there are only eight lines available: the timer uses one, the floppies and the fixed disk each require one, the keyboard uses one, one is used by the printer, and two are reserved for serial ports COM1 and COM2. This leaves only one spare line. The easiest way to expand the number of serial ports on the PC is to devise a way to let the additional serial ports share the present COM1 and COM2 interrupt lines. The following is a method that will accomplish this, while also allowing the additional ports to use all the communications support already in BASIC.

The first step is to configure the additional port to a spare I/O address. The first two serial ports already have been set up by the BIOS ROM boot-up routines to start at I/O addresses 3F8 (COM1) and 2F8 (COM2). A good place for the third serial port is 3E8 (COM3), and for the fourth, 2E8 (COM4). Most expansion cards that contain additional serial ports allow the user to set these I/O addresses via jumpers or dip switches on the card. The port that is selected as COM3 should be the one that has its interrupt line connected to IRQ4 at the card edge (COM1's interrupt), and the COM4 port should be the one with its interrupt line connected to IRQ3 (COM2's interrupt). All of the examples included here assume that COM3 and COM4 are set to the I/O addresses that have been recommended above. If different addresses are used, the user should be sure to change the appropriate numbers in the examples.

The serial ports are initialized to the correct parameters (baud rate, parity, etc.) in BASIC through the use of the OPEN"COMx: . . . " statement. In order to initialize the additional port(s) using this statement, the "RS232_BASE" pointer in the BIOS data area must be temporarily adjusted to point to the additional port(s) before using the OPEN statement. An example of how this is done (for the COM3 I/0 address chosen above) is shown in listing 1.

This example also illustrates how to set up parameters that BASIC does not allow, such as a baud rate greater than 9600 (38400 baud in this case). As shown, this is done by writing directly to the 8250 UART registers using the OUT statement, in lines 92 through 96 (see the *Technical Reference Manual* for details). COM1 can be used at 38400 baud in this way with very little problem. Interrupt priorities must be given attention, though, when more than one serial channel is in use. The COM2 interrupt has a higher priority than the COM1 interrupt, and therefore can cause a loss of COM1 data if both serial ports receive data at the same time.

In this example, COM1 has been set up as file number 1, and COM2 is file number 2. The PRINT# and the INPUT$ commands can now be used to send and receive data from those ports, by using the appropriate file number. In order to access port 3 (COM3) using these commands, BASIC must be switched over to that port by disabling the COM1 UART and activating the COM3 UART. This is done by disabling the COM1 UART's Interrupt Enable Register and Modem Control Register (the DTR and RTS lines), and then enabling the same registers in the COM2 UART. In order to access the COM3 UART, the "RS232_BASE" pointer, mentioned above in the initialization description, must again be adjusted to point to COM3. To return to the original ports, this process is reversed. Two subroutines that will perform this switchover (both directions) are provided in listing 2 (COM3COM1.BAS) and listing 3 (COM1COM3.BAS) A word of caution, however: be certain that neither COM channel (COM1 or COM3) is sending data *to* the PC when the switchover is being made; otherwise BASIC will get confused.

If this constraint cannot be met in a particular system, then these subroutines should be translated into machine language subroutines (start with a CLI instruction to disable interrupts, and end with STI to re-enable).

Jack Wright works in the hardware and software development department of a large electronics firm in New Jersey.

LISTING 1: OPEN3COM.BAS

```
70 '***** OPEN 3 COM Ports and Initialize ********
75 DEF SEG=0:POKE &H400,&HE8  'Point RS232_BASE to COM3 @3E8
76 OPEN "COM1:9600,0,7,1,CS,DS" AS #1:CLOSE #1  'Open COM3
78 POKE &H400,&HF8:DEF SEG    'Reset RS232_BASE pointer to COM1
80 OPEN "COM2:9600,E,7,1,CS,DS" AS #2  'Open COM2
90 OPEN "COM1:9600,N,8,1,CS,DS" AS #1  'Open COM1
92 OUT &H3FB,&H8B  'Access Divisor
94 OUT &H3F8,3  'Set to 38400 baud (-0-8-1)
96 OUT &H3FB,&HB  'Reset LCR and set 0-8-1   (COM1 = 38400-0-8-1)
```

LISTING 2: COM3COM1.BAS

```
130 'Subroutine - COM3->COM1 switchover
135 '(E9,F9=INT ENABLE REG; EC,FC=MCR)
140 OUT &H3E9,0:OUT &H3EC,0      'COM3 off
145 DEF SEG=0:POKE &H400,&HF8:DEF SEG
150 OUT &H3FC,&HB:OUT &H3F9,&HB  'COM1 on
160 RETURN
```

LISTING 3: COM1COM3.BAS

```
230 'Subroutine - COM1->COM3 switchover
240 OUT &H3F9,0:OUT &H3FC,0      'COM1 off
245 DEF SEG=0:POKE &H400,&HE8:DEF SEG
250 OUT &H3EC,&HB:OUT &H3E9,&HB  'COM3 on
260 RETURN
```



READ ONLY

A review of the IBM Personal Computer Family. Vol. 2, No. 1



GRAPHICALLY SPEAKING

E Pluribus Unum. IBM Personal Computer graphics hardware covers a lot of territory, from graphics cards and monitors to printers and plotters. Color monitors alone are available in four models that can satisfy varying levels of color graphics requirements, from home or office to the laboratory.

Two of the most recent, for example—the IBM PC Enhanced Color Display and the IBM PC Professional Graphics Display—offer advanced business and technical graphics capabilities. The IBM PC Enhanced Graphics Adapter can also be used to extend some of those capabilities to the IBM PC Monochrome Display and the IBM PC Color Display.

This growing array of hardware products is unified by a strong IBM Personal Computer graphics software development strategy, one that can dramatically improve your programming efficiency and broaden the application potential of your graphics programs.

Independence. Graphics software has traditionally been written for a specific graphics device and couldn't be run on a second device without complex and time-consuming reprogramming. By using the IBM Personal Computer Graphics Development Toolkit, however, you can now develop software that is compatible with all existing IBM PC graphics hardware products.

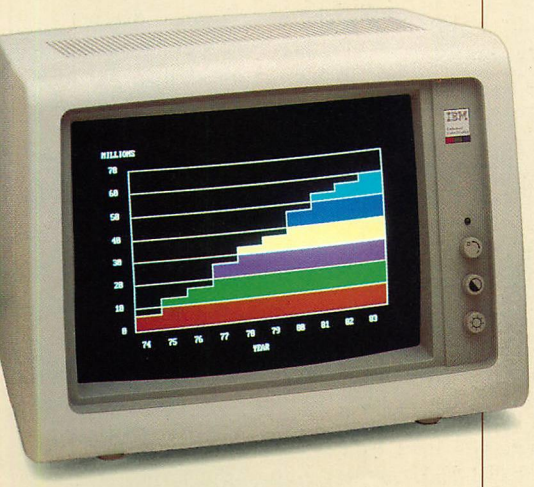
This is possible because the Toolkit contains a constant interface—the Virtual Device Interface—to which all applications can be written. The result is device-independent software.

The Graphics Development Toolkit allows you to program bit-map graphics to a 32K x 32K addressable point window and to combine graphics and text capability on a variety of graphics devices. The device drivers necessary for information exchange with existing IBM PC graphics devices are included in the Toolkit, as are a driver for the IBM PC*jr* Video Subsystem and language interfaces for the IBM BASIC, FORTRAN, C, and Pascal compilers and for the IBM Macro Assembler.

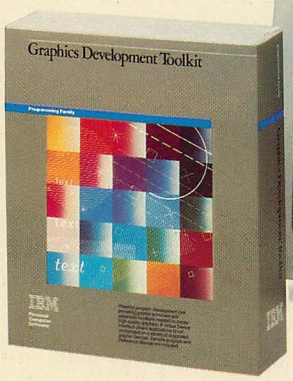
The right tools. Several products from the IBM PC Engineering/Scientific Series also play an important part in the IBM PC graphics programming strategy. All of them incorporate the Virtual Device Interface discussed above.

The IBM Personal Computer Graphical Kernel System—which is consistent with Draft ISO and ANSI GKS Standards—gives you a common high-level graphics language that can help further simplify your programming tasks. It also helps increase the portability of applications between computer systems.

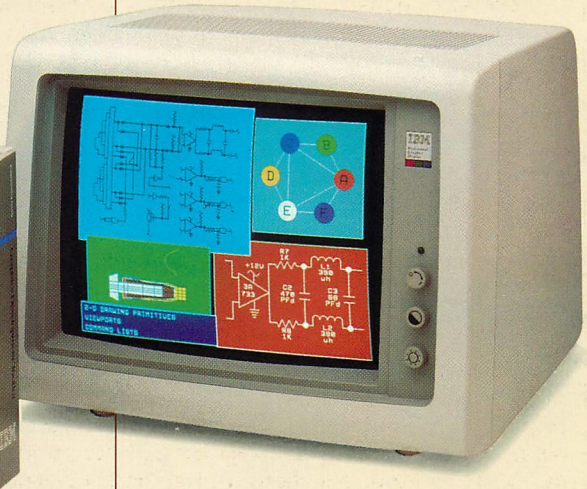
In addition, the IBM Personal Computer Plotting System provides a



IBM Personal Computer Enhanced Color Display



IBM Personal Computer Graphics Development Toolkit



IBM Personal Computer Professional Graphics Display

subroutine library of functions that help make it easy to produce a wide variety of charts and graphs. There's also a Metafile Interpreter available to facilitate retrieving and manipulating graphics images.

This range of IBM graphics programming tools is designed to help speed and simplify nearly every aspect of your graphics programming work. They can substantially reduce the time and tedium involved in program development, and the device independence they provide can help increase the flexibility of your finished programs. Device independence also helps extend the life—and marketability—of your programs, because applications developed with the Virtual Device Interface can interface with future generations of graphics devices.



HARDWARE NEWS

Lock and key. Troubled by people who try to peer without permission at sensitive business or personal data stored in your IBM Personal Computer? You can go a long way toward locking it up with the IBM Personal Computer Keylock Option.

Fifteen minutes and a screwdriver are all you need to install the Keylock Option on your IBM Personal Computer, IBM Personal Computer Expansion Unit, IBM Personal Computer XT, IBM Personal Computer XT/370, or IBM 3270 Personal Computer.

Once your system unit is outfitted with the Keylock Option and locked, it will be difficult for someone without the proper key to access the hardfile and all the valuable software it contains. Also, other users in a network won't easily be able to access or tamper with data stored on your system. In fact, when the Keylock Option is installed, the system unit can be powered up only with the key and can't be powered up through the CRT plug port.

And with the Keylock Option locked in place, the system unit cover can't be removed—short of forcible entry—by just anyone who might want to browse around inside your IBM PC during off hours.

Small packages. If you need more memory but don't have a full-size slot available in your system unit, the IBM Personal Computer 256KB Memory Expansion Option may be the answer. It offers 256KB of additional memory on a short card (5 inches rather than 11 inches) with a comparably diminutive price.

That makes it ideal for adding memory to the IBM *Portable* PC. This Memory Expansion Option is also a compact way to beef up your IBM Personal Computer or IBM Personal Computer XT (which has two slots for short cards).

Talkies. The combination of film and sound revolutionized the movies. Speech capability may soon spell an equally big change for computers. The IBM PC*jr* Speech Attachment is a step in that direction.

It's a side-attached option for the PC*jr* that permits speech and sound under control of software such as IBM Writing to Read.* The Speech Attachment contains 196 words and sounds in its ROM. Cartridges manufactured with prerecorded speech can be used under program control. And with the purchase of a microphone and the proper software, you can even record your own speech data on an IBM PC*jr* diskette.

So far, at least, the last word is ours.

*Developed by Dr. John Henry Martin.



WHAT'S THE PROGRAM?

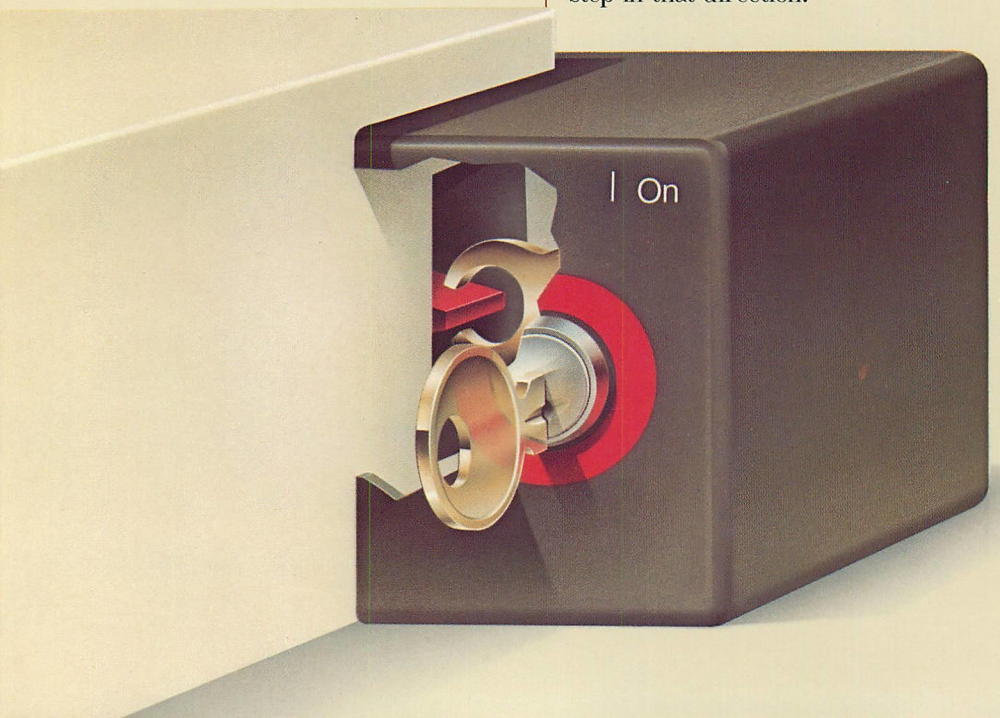
Retrieval. Whether you work with pen and paper or the latest word processing software, writing documents is only half the battle. Try finding them again a month later.

We don't claim to have discovered a better system for paper filing. But a new software package from IBM—Office Correspondence Retrieval System (OCRS)—does promise to make life a lot easier for those who store written work on a fixed disk or who have a library of documents stored on diskettes.

OCRS can help in two ways. First, it makes document abstracts and stores them in a summary file for future reference. OCRS automatically searches out keyword information such as date, subject, sender, or any other significant word. You can also add keywords other than those actually contained in the document.

Second, and most important, simple English language queries will prompt OCRS to locate the original document. A document search request can be entered as individual words or complete sentences. You don't need to learn a special query language.

OCRS can abstract and retrieve any type of file containing ASCII text such as letters, charts, and computer programs. It can also directly abstract documents written with IBM



Help protect your software and hardware with the IBM Personal Computer Keylock Option



IBM PCjr Speech Attachment

Writing Assistant, IBM PCWriter, and WordStar® and documents using the IBM Revisable Form Text Document Content Architecture (RFTDCA). Documents can be converted to RFTDCA data format by IBM DisplayWrite 1 and 2 and PCWriter.

With OCRS, missing reports may be a thing of the past.

Evolution. Like their human language counterparts, computer languages and operating systems change and evolve. Occasionally, an entirely new dialect crops up, such as the IBM Personal Computer XENIX® Operating System.

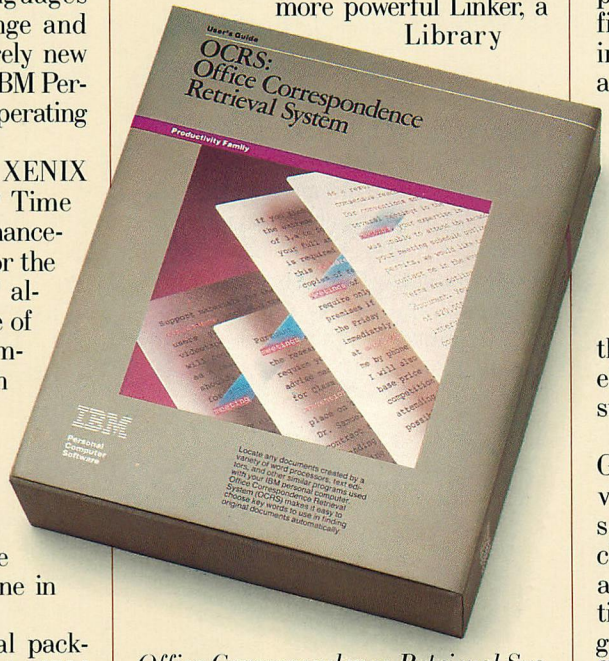
IBM Personal Computer XENIX is derived from the UNIX® Time Sharing System. Several enhancements designed specifically for the IBM Personal Computer AT allow you to take full advantage of its power. IBM Personal Computer XENIX supports both single-user and multi-user configurations. It also enables you to run several programs at the same time—you can, for example, compile a program in the background while you edit one in the foreground.

There are two additional packages available to be used with the IBM Personal Computer XENIX operating system that deserve special mention. First, the IBM Personal Computer XENIX Software Development System gives you tools to generate code suitable for either XENIX or IBM Disk Operating System (DOS) operating environments. Second, there's an IBM Personal Computer XENIX Text Formatting System that can help simplify the production of technical reports, memoranda, formal papers, and documentation—it's especially useful for publications that require technical or scientific formats.

IBM DOS has been updated twice recently. DOS 3.0 provides all the functions contained in DOS 2.1 plus enhancements to support the IBM Personal Computer AT. DOS 3.1 incorporates further enhancements that support the IBM Personal Computer Network.

There are also new versions of the IBM BASIC Interpreter and of the IBM Macro Assembler. BASIC 3.0 contains several noteworthy new functions that provide access to user-installed device drivers. They are: SHELL, IOCTL and IOCTL$, ERDEV and ERDEV$, and ENVIRON and ENVIRON$.

The recent 2.0 version of the IBM Macro Assembler supports both the 8088 and 80286 processors and the 8087 and 80287 Math Co-processors. Other additions include a new more powerful Linker, a Library Manager, and a Structured Assembler Language Preprocessor. And you can use the IBM Professional Debug Facility to put the finishing touches on your assembler language programs.



Office Correspondence Retrieval System Software from IBM

See your authorized IBM Personal Computer dealer or IBM Product Center about an economical trade-up from your 3.0 version of IBM DOS to version 3.1 or from Macro Assembler version 1.0 to 2.0.

WordStar is a registered trademark of MicroPro. XENIX is a registered trademark of Microsoft Corporation. UNIX is a registered trademark of AT&T's Bell Laboratories.



BUDDING USER GROUPS

Getting started. Ever considered forming a group to exchange ideas about using your IBM Personal Computer, but never got around to sorting out all the start-up details? Or, once past that first stage, does your group find it difficult to come up with new information, presentation materials, and connections with other groups?

Help is at hand.

Because of the growing interest in PC user groups all across the country, IBM has expanded its efforts to encourage new groups and to support existing ones. There's no charge for this assistance, and all groups—whether they have 10 or 1,000 members—are eligible for the same basic level of support.

For starters, the IBM User Group Support department will provide a package that introduces you to some of the basics of organizing a club. It includes a sample constitution and bylaws, suggestions for officers' titles and duties, and a list of other groups already in the program.

Staying started. Once the initial burst of enthusiasm is past, a PC user group needs more than a common interest to maintain its membership—it needs some focus for that interest. IBM can provide information and materials to help keep your group going.

Perhaps the most impressive

form of support is a monthly newsletter on diskette, complete with color and sound. It includes reviews of new products, editorial commentary, and technical tips. The newsletter also carries reprints of the best articles from participating group newsletters, so you can follow the activities of other user groups around the country.

Other sources of useful information are the PC User Group Phone Line and PC User Group Bulletin Board System. You can use the phone line to get answers to questions about the organization and functions of a user group and to find out about other groups in your area.

The bulletin board, which can be accessed through your IBM Personal Computer, carries new production information from the day of announcement. It also provides a means of communicating with other PC clubs.

Finally, to provide topics of interest for your regularly scheduled meetings, IBM will send timely presentation and demonstration materials. Better still, group officers can use the phone line to request guest speakers from IBM for special meetings.*

For more information about participating in the IBM User Group Support program, please write to: IBM User Group Support, IBM Corporation 2900, P.O. Box 3022, Boca Raton, FL 33432.

*The availability and frequency of guest speakers depend on the size of the group, its location, and meeting night.

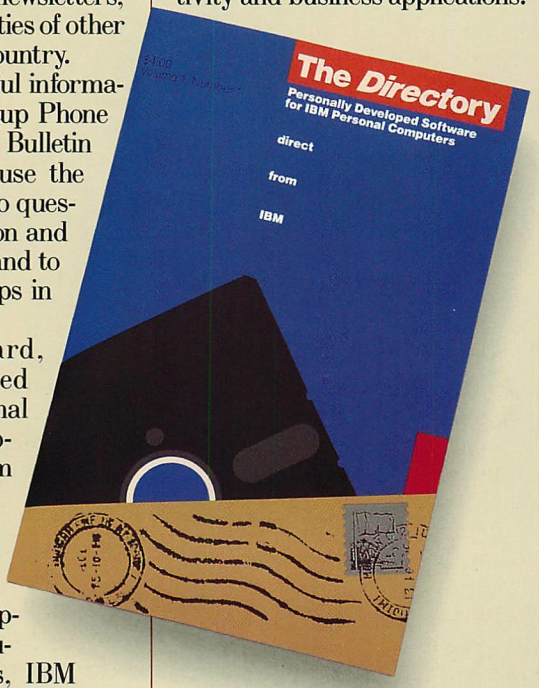


HARDCOPY

Hidden talent. Think of the many entertaining and useful programming ideas that must exist out there but never find their way to market.

The IBM *Directory* of Personally Developed Software gives you direct access to some of that hidden talent. It's a catalog of new programs developed by individuals for the IBM Personal Computer Family.

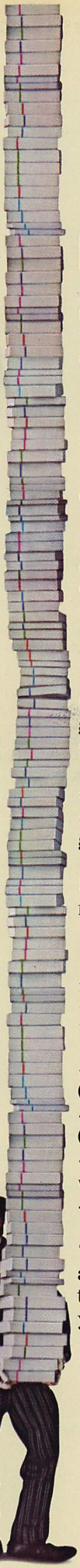
The best news is the prices. Programs listed in the *Directory* sell for as little as $14.95. They cover a wide range of interests, from entertainment and education to personal productivity and business applications.

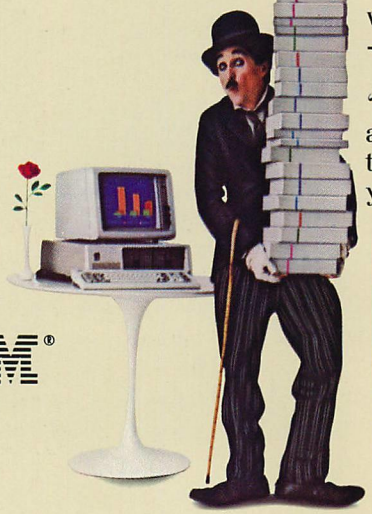


The Directory of Personally Developed Software from IBM

Each program in the *Directory* has a full description that includes system requirements and illustrations or color photos of representative screens. Programs may be ordered by mail or through an 800 telephone number.

To subscribe to the *Directory* call 800-IBM-PCSW.





IBM®



TIPS AND TECHNIQUES

Added color. Bored with the black screen that appears on your IBM PC Color Display when you boot up your system? There are lots of other color possibilities, and the brief program below shows you how to set them from DOS.

It will give you a display with a black border around a rectangle 80 columns wide and 25 lines high. The program can be used in an AUTOEXEC.BAT file to produce a starting color, and DEBUG will maintain the color you set.

All you have to do is substitute number or letter values for the colors you want where the ?? appear in the following program. For the first ?, substitute one digit (0-7) for the background color. For the second ?, substitute either a digit or a letter for the foreground color (1-7 for regular colors, 9-F for intensified colors). For example, 28 will give you grey text on a green background. For a complete listing of the color codes, see the Color Statement section of your IBM BASIC manual.

To set your screen colors, do the following from the DOS prompt:

```
A>debug color.com
File not found (ignore this message)
-rcx
:20
-e 100 2b c0 1e 50 b8 03 00 cd 10 b8
00 06 b9 00 00 ba
-e 110 50 20 b7 ?? cd 10 b4 02 ba 00
00 b7 00 cd 10 cb
-w
writing 20 bytes
-q
```

Thereafter, you need only type "color" at the initial DOS prompt after booting your system to change the display from black and white to your preset colors.

For more information about IBM Personal Computer products discussed in this issue of *Read Only*, see your authorized IBM Personal Computer dealer or IBM Product Center. To learn where, call 800-447-4700. In Alaska and Hawaii, 800-447-0890.

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Little Tramp character licensed by Bubbles Inc., s.a.

Custom Commands

Replacing DOS internal commands requires more steps and precautions than replacing DOS external commands.

TECH NOTEBOOK 33

TED MIRECKI

DOS does many things very well, but it has its weak points. Users who dislike the way DOS performs certain functions can write programs to perform those functions in a different way. And, in some cases, a new method may be considered to be so much better or safer that all users of a given system should be using the new program, and not have access at all to the old DOS command.

For DOS external commands, this is easy: just delete the DOS program and rename the new program with the name of that command. The situation is different for internal commands. For instance, a programmer may want to implement a new version of the ERASE (DEL) command. Normally, users would be notified that, henceforth, they are to use the XDEL command (or whatever name is given to the new program) and never type in DEL or ERASE. But those standard commands are still available, with no safeguard against someone using them, either out of habit or because they have just discovered in the manual.

The solution is to patch the DOS command processor, COMMAND.COM, so that the old internal command is replaced. A table within the command processor holds the list of internal commands; it is easy to find and change with DEBUG. The following example replaces the DEL command.

First, copy COMMAND.COM and DEBUG.COM to a spare disk or subdirectory to avoid damaging the original. Make this directory the current one on the default drive, then type:

DEBUG COMMAND.COM

Display the registers with the R command, noting the contents of the CX register (it contains the length of COMMAND.COM). For DOS 2.0, it will be 4500. Now search for the command to be disabled with the following:

S 100 L4500 'DEL'

The value following the L should be the contents of CX displayed in response to the R command. DEBUG responds with the location of the characters in the command:

xxxx:3AEB

The first four digits will vary depending on the configuration of the system; the second four may vary depending on the DOS version (this example assumes DOS 2.0). Next, display the file from this address:

D 3AEB

On the right side of the screen will be a list of internal commands beginning with the one entered in the S command. Overwrite the command to remove it from the list:

E 3AEB ' '

Now write out the file with the W command, and exit DEBUG with Q. Be sure that an unmodified copy of COMMAND.COM is available on a backup disk, then copy the modified version from the current directory to the root directory of the boot-up drive. The DEL command will become inoperative the next time the system is booted from the disk containing the modified COMMAND.COM.

Test the new command processor by running every internal command. All of them should work except DEL (or whichever command was disabled), for which the "Bad command or file name" message should be returned. If other internal commands are unrecognized, or the system begins to behave strangely, start over with an unmodified copy of COMMAND.COM on the root directory of the boot drive.

With appropriate changes, this procedure may be repeated for any command. Certain character strings appear in more than one command (for example, REN and RENAME), and DEBUG shows several addresses in response to the S command. The user must display at each of these addresses to determine the position of the desired command.

Overwriting the command names with blanks will make them totally unavailable. To make commands available under different names, just enter the new name instead of blanks between the quotes in the E command. (When disabling the DEL command, for example, it would be possible to leave it accessible to certain users by replacing it with some unlikely string, such as $!@.) The new name must be exactly the same length as the old and contain only legal file name characters.

The list of internal commands is kept in the transient portion of COMMAND.COM, which resides in high memory and which may be overwritten by programs when they need to use that part of memory. Every time DOS regains control, it checks to see if the transient portion of COMMAND was changed, and if so, reloads it from disk. Since the procedure given here changes COMMAND.COM, will DOS now reload it, even if the last program did not overwrite it? No, because the state of COMMAND after a program terminates is compared to the state at boot time, not to some predefined state.

When internal commands are replaced with external ones, the new commands will work only if the corresponding program files are accessible. Also, external commands take longer to execute because the program file must be located and loaded. But, in most cases, the command being replaced performs disk access anyway, so the extra time to load a program file will be hardly noticeable.

Ted Mirecki has a master's degree in computer science and 20 years of experience in information processing. He works as a corporate planner and is responsible for developing decision support systems on a wide variety of hardware from micros to mainframes.

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100 ea, DS/DD, 40T (IBM, H/P)	$ 750	$ 295
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10 ea, DS/DD 48T(IBM,H/P)	$ 69	$ 35
MAXELL, 10 ea, SS/DD,MD1(Apple)	$ 55	$ 19
10 ea, SS/DD, 3½" (MAC)	$ 60	$ 35
10 ea, DS/DD, MD2 (IBM)	$ 75	$ 26
10 ea, DS/QD Hi Dens(IBM-AT)	$ 77	$ 49
MEMOREX, 10 ea, SS/SD, 3½"(MAC)	$ 65	$ 35
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10 ea, DS/DD, MD34 (IBM)	$ 84	$ 32

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FX100—160 cps, 136 col.	$ 849	CALL
JX80—Color Printer, 160 cps	$ 399	CALL
LQ1500—200 & 67 cps	$1395	CALL
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MANNESMANN TALLY,		
Spirit—80 col., 80 cps	$ 399	$ 299
160—80 col., 160 cps	$ 798	$ 568
180—132 col., 160 cps	$1098	$ 778
OKIDATA, Okimate 20, Color, Hi Res	$ 268	$ 208
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83A—132 col., 120 cps, para.	$ 749	$ 599
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1114—same as 1014 w/T&F, 2c & prop.	$ 599	$ 439

MONITORS

AMDEK, Color 300 Comp/Audio	$ 349	$ 249
Color 500 Comp/VCR/RGB/Audio	$ 525	$ 395
Color 600 Hi Res, RGB /Audio	$ 599	$ 459
Color 700 Ultra Hi Res, RGB	$ 749	$ 549
Color 710	$ 799	$ 599
300G, 12" Green	$ 179	$ 129
300G, 12" Amber	$ 199	$ 149
310A, 12" Amber, (IBM)	$ 230	$ 159
PRINCETON, HX-12, Hi Res, RGB	$ 795	$ 495
SR-12, Hi Res, RGB	$ 799	$ 599
Scan Doubler for SR-12	$ 249	$ 179
MAX-12, Amber (monochrome)	$ 249	$ 199
QUADRAM, Amberchrome, 12" Amber	$ 250	$ 165
Quadchrome 12" RGB Color	$ 695	$ 495
Quadchrome II, 14" RGB Color	$ 650	$ 450
Quadscreen 17" 968x512 w/cable, Hi Res	$1995	$1595
ZENITH, ZVM122, 12" Amber	$ 159	$ 95
ZVM123, 12" Green	$ 149	$ 89
ZVM124, 12" Amber	$ 200	$ 149
ZVM135, 12" Color	$ 599	$ 499

MODEMS

ANCHOR, Signalman Mark XII (IBM)	$ 399	$ 269
HAYES, 2400B External Modem (IBM)	$ 899	$ 699
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Smartcom II Software (IBM)	$ 149	$ 99
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PROMETHEUS, ProModem 1200B (IBM)	$ 399	$ 289
QUADRAM, Quadmodem, Internal (IBM)	$ 595	$ 425
Quadmodem, External (IBM)	$ 695	$ 495
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PC1200, Internal (IBM)	$ 499	$ 379

ACCESSORIES

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Ruby, 6 outlets, 6' cord, filter	$ 90	$ 52
Sapphire, 3 outlets, w/filter	$ 80	$ 46
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Lime, 6 outlets/floor	$ 90	$ 45
Orange, 6 outlets/floor	$ 140	$ 60
Peach, 3 outlets/wall	$ 98	$ 39
Kiwi, 1 outlet/wall		CALL
NETWORX, Wiretree, 4 outlet, w/filt & surge	$ 70	$ 39
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200 Watts, PC200 for IBM-PC	$ 499	$ 399

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ZENITH Z150, 256K, 2 320K Disk Drives, MS DOS 2.1, 8088 Chip, 2 S/P — CALL

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Megaflight 100, Internal 10 meg kit	$ 895	$ 795
Masterflight, 20 meg, tape, surge prot.	$1595	$1150
MAYNARD, 10 meg kit, Int, w/Sandstar Cont.	$1595	$1150
QUADRAM, Quaddisks Int. w/controller, Full Line		CALL
RANA, External 10 meg w/controller	$1495	$1095
Internal 10 meg w/controller	$ 995	$ 795

DISK DRIVES

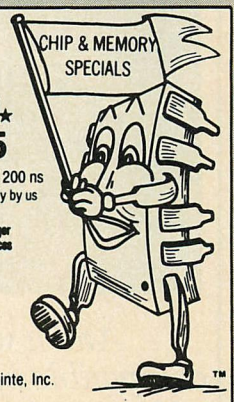
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CDC, Limited 30 day warranty; Call for quantity prices		
Full Ht, 320/360K, DS/DD	$ 529	$ 189
Half Ht, 320/360K, DS/DD	$ 395	$ 149
Half Ht. Dual Drive Installation Kit	$ 30	$ 16
MAYNARD, Controller Card w/para port	$ 300	$ 185
Controller Card w/serial port	$ 310	$ 195
Sandstar Cont Card (accepts 3 modules)	$ 265	$ 205
PERFECT DATA, Head Cleaning Kit	$ 16	$ 12

OTHER HARDWARE

	LIST	OUR
AST, SixPakPlus,64K,S/P/CC+S/W	$ 395	$ 245
SixPakPlus, 256K, S/P/CC+S/W	$ 695	$ 395
SixPakPlus, 384K, S/P/CC+S/W	$ 895	$ 465
Game Port for SixPak	$ 50	$ 39
Preview, Graphics Card w/para, 64K	$ 399	$ 299
Advantage™, Multif. Bd for AT	$ 595	$ 445
I/O Plus II, S/P/CC	$ 215	$ 150
I/O Plus II, S/P/CC/G	$ 265	$ 185
I/O Plus II, 2S/P/CC/G	$ 315	$ 215
MonoGraphPlus™P/CC(forLotus)	$ 495	$ 375
PCNet, Starter Kit, PC002	$1090	$ 795
PCNet, Circuit Board,PC001	$ 695	$ 365
ComboPlus Products IN STOCK		CALL
MegaPlus Products IN STOCK		CALL
CURTIS, UNI-I, Monitor tilt/swivel base	$ 50	$ 39
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Vertical CPU "System Stand"	$ 25	$ 19
Monochrome Exten Cable Pair	$ 50	$ 35
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Game Adapter Module	$ 49	$ 43
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Memory Module 256K	$ 422	$ 357
10 meg Hard Disk Kit & Cont Card	$1595	$1150
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System Card, 64K	$ 395	$ 275
System Card, 256K	$ 625	$ 450
MOUSE SYSTEMS, PC Mouse & Paint	$ 295	$ 189
PARADISE, Modular Graphics Card	$ 395	$ 285
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Color Bd & Draftsman, 16 color w/Para	$ 559	$ 395
QUADRAM,		
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Quadboard 256K, to 384K, S/P/CC	$ 675	$ 395
Quadboard, 384K, S/P/CC/G	$ 795	$ 495
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Quadboard II, 64K, to 256K, 2S/CC	$ 395	$ 265
Quadboard II, 256K, 2S/CC	$ 595	$ 395
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Quad 512 + 256K w/serial port	$ 550	$ 420
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Quadnet IX	$1995	$1745
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BUSINESS

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BRODERBUND, Bank St. Writer(PC or Jr)		$ 80	$ 50
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DOW JONES, Investment Evaluator		$ 139	$ 99
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Trader's Accountant	$ 350	$ 219
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Perfect Combo (Jr) (Write/Spell/Thesaus	$ 139	$ 89
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COMX, Fastrak™, RAM/Disk emulator & printer spooler. For any PC/DOS vers. or RAM Card.Menu Driven	$ 100	$ 59
DIGITAL RES., CP/M-86™ (PC/XT)	$ 80	$ 39
CBASIC 86™ (CP/M-86)	$ 200	$ 135
CBASIC Compiler(CP/M-86 or PCDOS, ea)	$ 600	$ 395
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FUNK SOFTWARE, Sideways	$ 60	$ 40
HAYES, Smartcom II (Data Comm.)	$ 149	$ 99
LIFEBOAT, Lattice C	$ 500	$ 295
MICROSTUF, Crosstalk XVI (PC or Jr)	$ 195	$ 129

UTILITIES

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MICROSOFT, Macro Assembler	$ 100	$ 69
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COBOL Compiler	$ 700	$ 459
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PASCAL Compiler	$ 300	$ 199
MOUSE SYSTEMS, PC Paint	$ 99	$ 69
NORTON, Utilities 2.0 (14 programs)	$ 80	$ 54
OPEN SYSTEMS, BASIC Interpreter	$ 195	$ 145
ROSESOFT, Prokey	$ 130	$ 79
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ARMONK, Executive Suite	$ 40	$ 27
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CIRCLE NO. 126 ON READER SERVICE CARD

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a complete internal half-high 60 megabyte tape backup system for your IBM® PC, XT, or AT for only $995

Complete with tape drive, controller, and software

And it works easily with all IBM compatible operating systems. Simply tell your tape drive you want to backup or restore the entire hard disk, or any file, or backup or restore by subdirectory, date, or everything since you last backed up.

Now you won't have to wait for the difficult to find hard-disk version of the IBM AT (model 99). You can buy the floppy disk IBM AT (model 68), add our hard disk and tape drive system for about what you'd pay for the AT hard disk upgrade alone. It's almost like getting the tape drive free.

Let's face it, we've all heard the horror stories of people who've lost data on their hard disk. True, it doesn't happen often, but then disaster seldom does. With the amount of data you can put on a hard disk these days, no one in business can afford even a small disaster.

When did you last backup your hard disk?

Oh, you did it once with floppies and it was so time consuming that now you've convinced yourself nothing will go wrong? In other words, it can't happen to you. And besides, at the prices they're asking for tape backup—$2,000 and up—you're willing to take a chance. You've seen some tape drives for less, but you have to buy an expensive hard disk to go with it, and you've already got a good hard disk. Where can you turn for relief?

IBM Compatible tape drive system complete for $995

The Express Systems™ tape drive comes complete—half-high tape drive, controller, and software—for only $995. It's absolutely IBM compatible—all 60 megabytes of it.

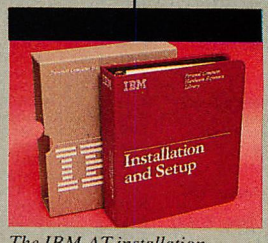
You can use your tape drive in the event your hard disk fails. And if you have to replace your hard disk, the tape's ability to read bad sectors will let you replace your hard disk with another even if the new one is not error-free. The tape requires very low power, too.

And it doesn't poke along. It reads and writes at 90 inches per second (ips) and transfers data at up to 3.75 megabytes per minute in the streaming mode. You don't have to be a rocket scientist to figure that you can perform an image backup of a 20 megabyte hard disk in about 5 minutes. But practically speaking, once you back up your hard disk completely for the first time, you never need to do more than invoke the archive command—that convenient command that tells your new tape drive to back up everything since you last backed up. If you backup as often as you should, your Express Systems tape drive will finish the job virtually in seconds.

The Express Systems software has additional benefits, like enabling you to use PC DOS terminology such as "*", "*.*", and "?". It also has a built-in reformatter, built-in verification (to make sure you transferred what you thought you did), and it's prompt driven, which means it asks you exactly what you want to do.

Easy to install

Before you get intimidated about installing our tape drive internally, you should understand that IBM doesn't think it's too difficult. They're selling IBM PC ATs with instructions on how to add additional hard disks in the *Installation and Setup* manual that comes with the AT.



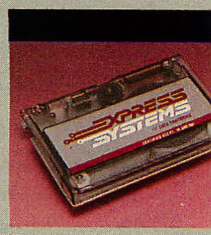
The IBM AT installation manual shows how easily you can install internal storage drives yourself.

Our instructions for installing your new Express Systems tape drive follow IBM's clear, simple instructions.

We even provide the tape cartridge

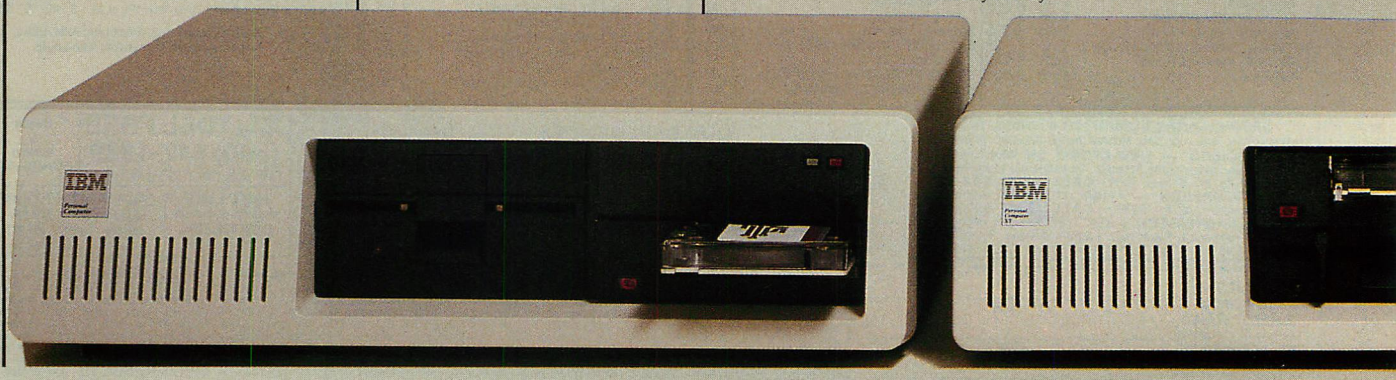
Most people don't realize that the tape cartridge contains most of the critical mechanisms to insure data integrity. In order to be sure that you get the best insurance for your data (after all, isn't that why you're buying it) we encourage you to use Express Systems' specially tested tape cartridges. We're not going to kid you and tell you others won't work, but here's what's special about Express Systems' tape cartridges.

First, they are tested down four separate tracks from end-to-end, not just down the center of the first 150 feet, like some others do. We use three screws to hold the cover on instead of four. This simple triangular arrangement keeps the baseplate flat, just like three legs work better than four to make a table steady. Since all tape drives reference everything to the baseplate, this alignment is critical. We also use special rollers to dissipate posible static electricity buildup—something that can ruin your whole day.



The Express Systems tape drives come with Express Certified™ 555 or 600 ¼-inch tape cartridges with quadruple end-to-end testing for extra insurance of your data.

And finally, we will sell you tape cartridges in boxes of three instead of the usual five. So, you get higher quality with a smaller quantity commitment. And we compound the savings with a lower per unit price, just $35.00 instead of the usual $45.00 most retailers charge.



Need a hard disk?

Depending on whether you have an IBM PC, XT, or AT you may want additional hard disk storage. We have those too. We offer 10, 21 and 31 megabytes of formatted hard disk storage.

For the most part, our drives are made with plated media, which means there is less chance to damage them. (Let's face it, the oxide that most disks come with is nothing more than rust.) We then test the drives, pre-format them, and install DOS 3.0 so that you're ready to begin transferring files. We even include DOS 3.0 documentation.



Express Systems offers 10, 21, and 31 megabytes of formatted storage in the half-high form so you have extra space for other storage options.

And they're 100 percent IBM compatible. The controller we send you for the XT is an upgraded version of the XT controller from the same company that makes the XT controller. In fact, the Express Systems controller is an improved controller which requires less power so that it is more reliable than any other standard controller.

We provide the power too.

If you want to upgrade your IBM PC, there just isn't any way around upgrading your power supply—if you want to have true XT or better capability. Some companies say that their hard disks don't require any increase in power—and they might be right. But don't add anything to your slots, because the minute you do, you'll need more power. That's the bad news.



Our 130 watt power will convert your PC to XT standards; and it's only $99.50 with any tape drive or hard disk order.

The good news is that our power supplies are inexpensive. How's $99.50 for an XT power supply? We mean a full 130 watts of power. The other good news is that it's held in by only 4 screws. Express Systems' power supplies can be changed in 20 minutes, a small price in time for the peace of mind to convert your PC to an XT-capable machine and avoid the unsightly "wart-like" power supply add-ons that some companies insist you paste on the back of your PC.

Express Systems Upgrade Kits

(Includes controller, software, and cable where appropriate)

IBM AT (model 99) to AT ExPlus™
1 half-high tape drive system — **$995**

IBM XT to XT ExPlus
1 half-high floppy and 1 half-high tape drive system — **$1095**

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31 Megabyte upgrade — **$2195**
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IBM PC to XT ExPlus
2 half-high floppies, 1 half-high 10 megabyte hard disk with controller, 1 half-high tape drive system and 130 watt power supply — **$2095**

But from a mail order house?

We get tired of the snide remarks some people make about mail order houses. The comments are usually spread by distributors and retailers who are getting cut out of 15 and 35 percent margins, respectively. If we went through distribution—you'd have the privilege of paying for large glass windows, rugs, salesmen, etc.—but we'd also be selling this tape drive for $1495.

We're not criticizing distributors and retailers. They perform a valuable service. But you don't need them if you know what you want. And you can certainly install it yourself. IBM has proved it with their instructions for self-installation that come with the new IBM PC AT.

And speaking of IBM, the next time you hear anyone criticize mail order as a way to buy computer equipment, remind them that IBM is now in the mail order business.

Warranty

We offer you a one year warranty on our hard disks—the same as IBM on the AT and 90 days on the tape drives. (It's all the manufacturer gives us.) If anything goes wrong with your tape or disk drive or hard disk, send it back in the box it came in. However, we have found that we can usually solve the problem over the phone. So call first for a return authorization number because we can't accept any returns without it.

Immediate delivery

We have four types of delivery: *Next Flight Out*℠ if you need it immediately: *Next Day Express*℠ and *Day After Tomorrow*℠ if you can wait a day or two; and our normal delivery—which we pay—if you can wait a few days.

Express Systems Product Line

Internal Tape System
Half-high tape drive, controller, & software — **$995**

Tape Subsystem
Tape system, controller, power, supply, cable, and chassis — **$1195**

Internal Tape & H.D. System
Tape & hard disk internal systems come complete with tape controller and hard disk controller, software, and cables. Hard disks are formatted and tested with DOS 3.0.

Tape drive & 10 MB H.D. — **$1695**
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Tape drive & 31 MB H.D. — **$2195**

Hard disks Kits
(includes Controller and cable)

10 megabyte hard disk* — **$695**
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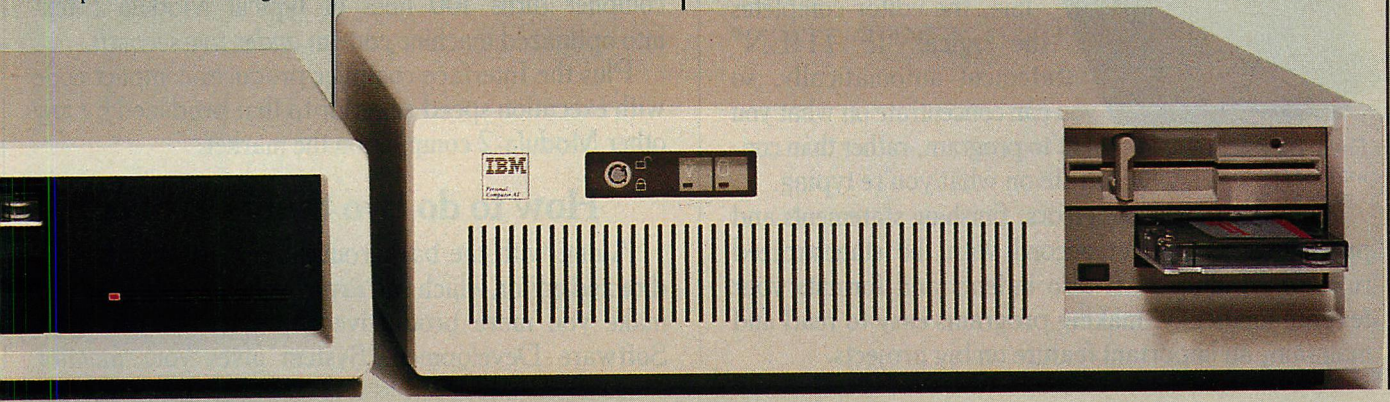
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CIRCLE NO. 143 ON READER SERVICE CARD

INTRODUCING
Interface Technologies' Modula-2 Software Development System

The computer press is hailing Modula-2 as "the next standard in programming languages." Modula-2 combines the strengths of Pascal with the features that made C so popular, like independent compilation and direct hardware control.

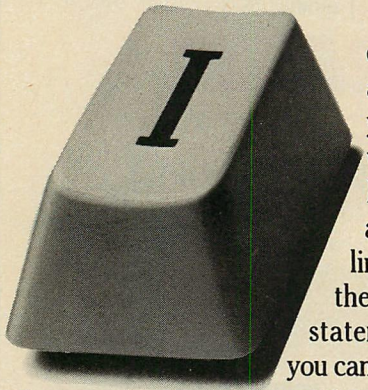
But until today, no company offered a Modula-2 system that made the development of software fast, easy and efficient. Now, though, there's a new tool at your disposal.

The fast, powerful tool for programmers

The breakthrough is here: Interface Technologies' new Modula-2 Software Development System for the IBM® PC, XT, AT and compatible computers to give programmers the same quantum leap in productivity spreadsheets and word processors gave to end-users. It can reduce monotonous wait time, will dramatically increase speed, help stop thoughtless mistakes, and free you to become more creative in virtually all of your programming efforts.

How to speed input and eliminate 30% of errors

Thirty percent of programming mistakes are syntax errors and simple typos in the program structure. Our "syntax-directed" Modula-2 editor does away with these time-consuming headaches once and for all.



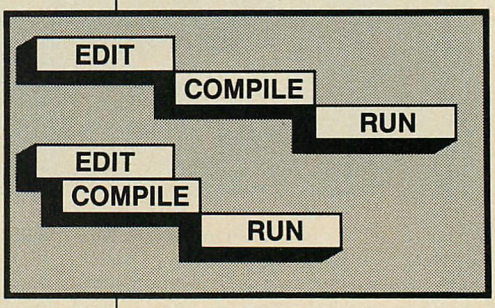
Enter complete statements with one keystroke.

It speeds input by cutting manual typing as much as 90%, letting you enter statements with a single keystroke. For example, if you type a capital "I" to begin a line, the editor completes the logical "IF THEN" statement automatically, so you can concentrate on what you want to program, rather than concentrate on what you're typing.

The editor locks out errors, finishing statements and procedures in perfect accord with the standardized rules of Modula-2. It also indents and formats your text automatically, making programs easy to read and maintain, an important feature on big projects.

And if you leave an undefined variable or data type, the editor detects the mistake and gives you the option of on-line "help" to correct it. No other programming text editor offers you so much innovation at any price.

How to turn "wait time" into "work time"



It not only has a faster compiler, it also saves time by compiling <u>while</u> you edit.

The vast majority of programming time is spent waiting, and the biggest slowdown is most often with compilers.

THE ANATOMY OF A

Our compiler turns wait time to work time with a new innovation that lets you compile in the "background."

With background compilation, your program is automatically compiled into object code line by line as you work, every minute you spend writing or editing a Modula-2 program!

When you're finished editing, all that's left for the compiler is a quick mopping up job that generates optimized native code in a single pass.

How quick is "quick"?

Thanks to background compilation and the fact that the compiler itself is so fast, Interface Technologies' compiler turns 100 lines of typical Modula-2 text into optimized machine code in *under five seconds.*

Plus the Interface compiler produces compact code with execution speed superior to that produced by any other Modula-2 compiler on the market.

How to do two things at once

Along with the background compiler and syntax-directed editor, which can save you hours every day and make you more productive, Interface Technologies' Software Development System gives your monitor

windows so you can refer to one file while you edit another simultaneously, saving you even more time.

Concurrent editing of two or more files is especially useful when doing programming work that's intended for separate compilation, and Interface Technologies has the only Modula-2 system on the market that provides you with this helpful benefit for developing software.

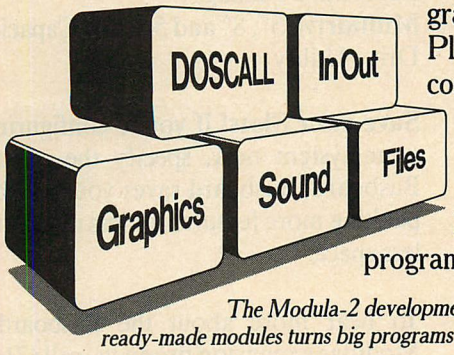


Work with multiple files faster, easier in windows.

How preprogrammed modules speed development

One of the advantages of Modula-2 is that it lets you build large, reliable programs quickly, by linking together many smaller "building-block" modules.

The development system's toolkit of precompiled program modules includes the standard Modula-2 library, and adds exclusive link-and-run modules for direct calls to the operating system, sound, and color graphics support. Plus you get low-cost updates from the Interface Technologies fast-growing library of new programming modules.



The Modula-2 development system's toolkit of ready-made modules turns big programs into smaller projects.

Increase productivity for $249

Interface Technologies' Software Development System is fast, powerful and unlimited. It works so well that it's the same tool Interface Technologies is using to write business and consumer applications in Modula-2.

For $249, you get the syntax-directed editor and compiler, linker, module library and tutorial that will have even modestly experienced programmers writing in Modula-2 in days. And you have full rights to your work; there's no license fee for programs you develop with the Interface Technologies system.

You can use it on any IBM® PC, XT, AT or compatible computer with two double-sided, double-density floppy drives and 320K RAM diskette.

You get a thoroughly indexed, comprehensive user's manual and free telephone support from Interface Technologies. But the most important thing you get is the future, and *the programming language of the future is Modula-2*, and now it's easier than ever.

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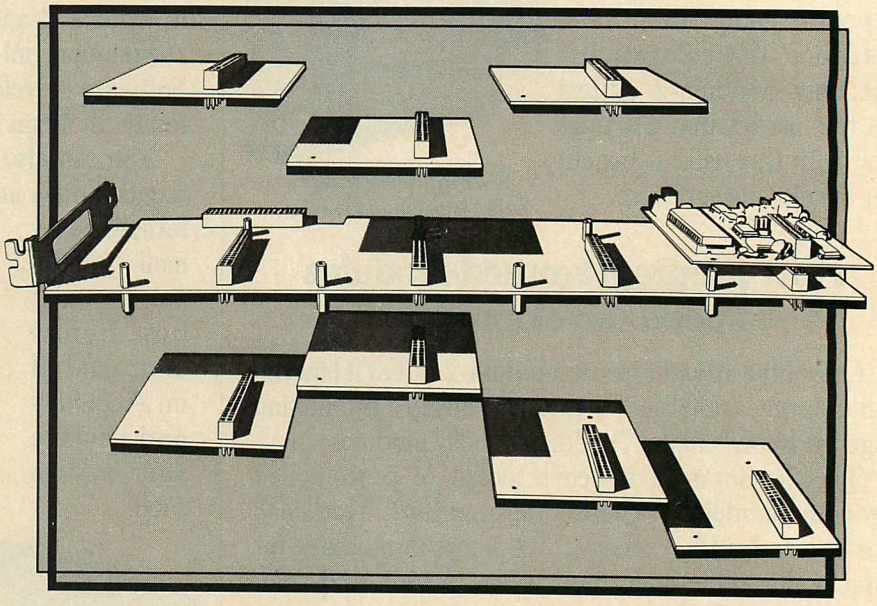
MODULA-2 SOFTWARE DEVELOPMENT SYSTEM

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More Modules Available! A full array of modules save you money while your system grows. Aquix has the largest line of modules and the only line of industrial and OEM modules for the System Integrator and Original Equipment Manufacturers.

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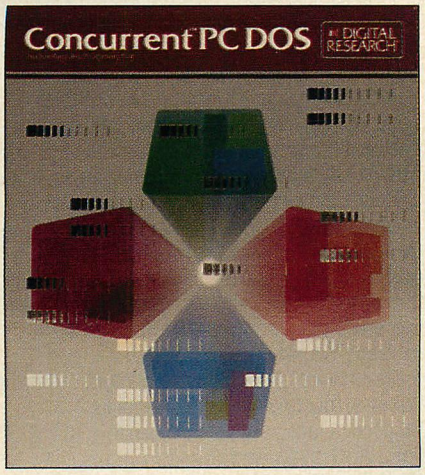
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Concurrent PC-DOS

Digital Research's new operating system combines multitasking and multiuser capabilities with some MS-DOS compatibility.



DON AWALT

Elderly women in tennis shoes using DOS for Sunday afternoons with WordStar, affluent families with a different operating system for every day of the week, and other recreational users are exceptions to the rule that operating systems should be replaced from time to time. For everyone else, the question is when?

The choice is not easy. All IBM PC operating systems work well, yet there are subtle differences between them. Should the IBM user abandon DOS, and if so, when? If these questions were posed to Digital Research, it would answer "yes" to the first question and "as soon as possible" to the second.

Digital Research is known for its expertise in developing operating systems. The company invented CP/M, the most popular 8-bit computer operating system in the world. The 16-bit version, CP/M-86, was introduced for the PC in 1981. CP/M-86 and its predecessors, Concurrent CP/M-86 (CCP/M-86) and CCP/M-86 with Windows, did not achieve the success that CP/M did because of the rapid growth in popularity of Microsoft's MS-DOS.

In its latest attempt to provide an alternative to MS-DOS in the IBM PC marketplace, Digital Research has introduced a new member of the CP/M family. Concurrent PC-DOS 3.2 is an important new product that may be the operating system of choice for a small group of MS-DOS users with specific needs.

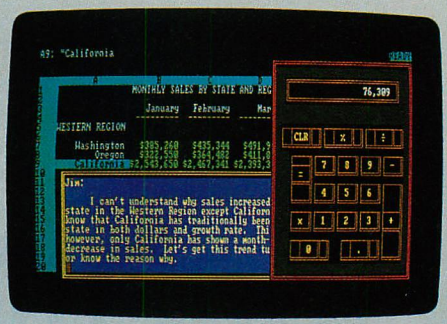
Examination of Concurrent PC-DOS reveals five significant features; four of them are technical advancements. First, the operating system supports multitasking with up to four windows. Multitasking is present in previous versions of CCP/M-86 but not in MS-DOS. Second, Concurrent PC-DOS supports a multiuser capability; up to three people can use a single PC. Third, the operating system runs programs written for MS-DOS with no source changes, no recompiles, and no additional hardware, although some limitations do exist. Fourth, Concurrent PC-DOS can be installed on a hard disk formatted for CCP/M-86 or MS-DOS with applications programs of either type.

The last is a marketing innovation—the name Concurrent PC-DOS. The press has called IBM's version of MS-DOS "PC-DOS." IBM has referred to it as IBM DOS or simply DOS. The name PC-DOS was never legally protected, and Digital Research has now claimed rights to it. To avoid confusion, in this article "IBM DOS" is used for IBM's version, and "C/PC-DOS" refers to Concurrent PC-DOS.

Digital Research has aimed its marketing thrust at three well-defined

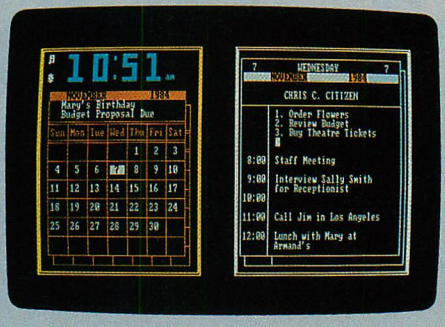
Replace this. With this. Instantly!



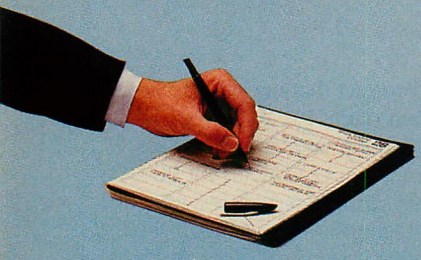


Calculator, Memo Window Over 1-2-3





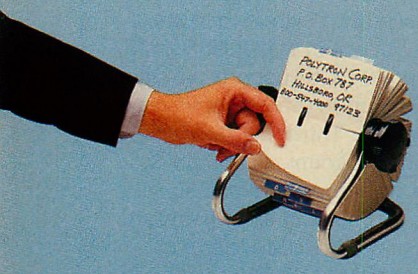
Alarm Clock, Calendar, Appt. Book





Filedex Over WordStar

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groups. The first audience consists of Fortune 2000 "power users:" IBM PC/XT owners who use two or more applications, such as Lotus 1-2-3, WordStar, dBASE II, or PFS-File. The typical user in this audience is a financial analyst or a business consultant, for whom the capability for quick and frequent switches between applications is critical.

The second audience uses data communications and requires multiuser or multitasking capability in business applications. These users periodically access Dow Jones or a similar database retrieval system while using Lotus 1-2-3 or WordStar. They may also manage small accounting offices, in which two or three persons use the same PC on a regular basis.

Software developers who learned to take advantage of concurrent capability on a minicomputer or mainframe are the final audience. These developers like to simultaneously compile one program, edit a second program, and list a third program on the printer.

TABLE 1: *IBM DOS Programs Tested under C/PC-DOS*

PROGRAM	COMPATIBILITY
*Home Accountant Plus	Y
*MultiMate	Y
*MultiPlan	Y
*Lotus 1-2-3	Y
*pfs:graph	Y
*pfs:report	Y
*pfs:write	Y
*SuperCalc 2	Y
*SuperCalc 3	Y
*VisiCalc	Y
*WordStar	Y
IBM Logo 1.0	Y
WordPerfect 3.0	Y
SSI P-Edit 2.3	Y
Turbo Pascal 2.0	Y
IBM Macro Assembler 1.0	Y
Crosstalk XVI 3.4	N
Sidekick 1.1	N
Spotlight 1.0	N
PC-Calc 1.06	N
dBASE II 2.4	Y
dBASE III 1.0	N
VDISK.SYS (IBM DOS 3.0 RAM disk)	N

**Programs with an asterisk were verified and documented by Digital Research Corp. to be compatible.*

Most programs that were developed under IBM DOS version 2.0 or later do not work under C/PC-DOS, because of IBM DOS 2.0 function calls that kill C/PC-DOS.

MORE THAN JUST A PRETTY BOX

The $295 price for C/PC-DOS buys a large documentation manual and five disks. The documentation consists of a section called *User's Guide*, another one called *Getting Started with Concurrent PC-DOS*, and release notes that are not included in the *User's Guide*.

The documentation for predecessors of C/PC-DOS included a programmer's guide that described function calls and other technical information; this guide must now be purchased separately. Digital Research has followed IBM's lead in separating its technical information from the rest of its documentation and charging extra for it.

C/PC-DOS does not have several programs that are included with IBM DOS: DEBUG, 8088 assembler, cross-reference utility, linker, and BASIC. Some of these are included in an optional Programmer's Pak, available for $70. This package has an assembler, library manager, linker, cross-reference utility, window source code, a user's guide and programming guide for GSX (graphics support), and a programmer's guide for C/PC-DOS.

C/PC-DOS requires 256KB of memory and two diskette drives. The recommended hardware configuration is 512KB of memory, a hard disk with a partition of 1.7MB and one floppy disk.

When C/PC-DOS and IBM DOS are compared, C/PC-DOS shines in four major areas: IBM DOS support, multitasking capability, multiuser capability, and CCP/M-86 support. An evaluation of the strengths and weaknesses of each feature will help users determine the suitability of C/PC-DOS for their needs.

If C/PC-DOS is installed on a fixed disk, it can exist in either an IBM DOS or a CCP/M-86 partition, depending on the user's preferences. If C/PC-DOS is in a CCP/M-86 partition, only CCP/M-86 software can be executed. If C/PC-DOS is in an IBM DOS partition, either CCP/M-86 or IBM DOS programs can be executed. All C/PC-DOS software is copied into the root directory, and the current IBM DOS subdirectory structure is preserved and supported. C/PC-DOS can read and execute both IBM DOS and CCP/M-86 diskette software.

A special set-up program must be run in order for C/PC-DOS to be used in IBM DOS partitions. This procedure renames the AUTOEXEC.BAT file, if the root directory has one, and creates a new AUTOEXEC.BAT file that loads CCPM.SYS so when IBM DOS is booted, C/PC-DOS is loaded automatically.

CCPM.SYS is the resident portion of C/PC-DOS that manages operating system requirements for CCP/M-86 and IBM DOS programs. When an IBM DOS program is running, CCPM.SYS redirects all operating system interrupts and function calls to IBM DOS software subroutines that still reside in memory. IBM DOS *sees* only one program that requires its services—CCPM.SYS. During execution of an IBM DOS program, CCPM.SYS uses IBM DOS file formats and other conventions. When a CCP/M-86 program is running, CCPM.SYS provides full CCP/M-86 support.

C/PC-DOS can create, format, or be loaded into a CCP/M-86 or IBM DOS disk partition. LOADCCPM is used to switch control of a fixed-disk partition between IBM DOS and C/PC-DOS without reloading files.

One significant limitation to C/PC-DOS is that it is compatible with IBM DOS version 1.1; thus, most IBM DOS features from version 2.0 and later will not work. This means that batch files using ECHO, SHIFT, IF, FOR, and GOTO will not work, nor will many IBM DOS programs that require IBM DOS 2.0 or 3.0 for proper operation.

C/PC-DOS does, however, support some IBM DOS 2.0 features: fixed disks, directory structures on IBM DOS media, back-up, restore, MKDIR, CHDIR, RMDIR, and 360KB disk drive format.

If a CONFIG.SYS file exists on an IBM DOS disk, that CONFIG.SYS file will be executed (and any device drivers installed) before C/PC-DOS assumes control through CCPM.SYS. Note, however, that installed device drivers will not run if they perform any IBM DOS 2.0 specific system calls.

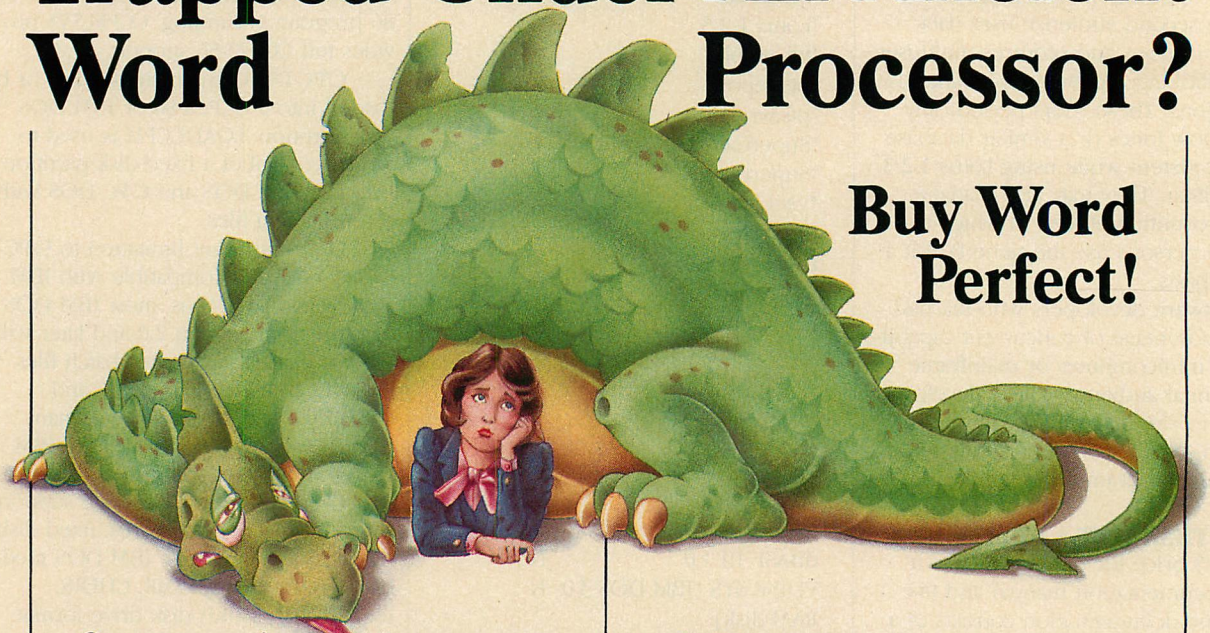
C/PC-DOS supports a second serial port and a second and third parallel port, hardware that was not made standard until after IBM DOS version 1.1. However, complete IBM DOS 2.0 support is expected to be released soon.

A major weakness of C/PC-DOS is the absence of pathname-search capability corresponding to the IBM DOS PATH command. Without it, accessing programs and files is more difficult. Running different applications will require changing subdirectories.

To allow limited access to programs outside the current directory, C/PC-DOS provides two floating drives (N: and O:) and the ability to redefine the system disk. The floating drives and system disk can be equated to any subdirectory and drive by using CHDIR and SYSDISK. If a program is not located on the current drive and subdirectory, the system disk is automatically searched. A file's location can also be specified by preceding the file name with N: or O:.

C/PC-DOS was tested to determine what IBM DOS features were not included with C/PC-DOS and how effec-

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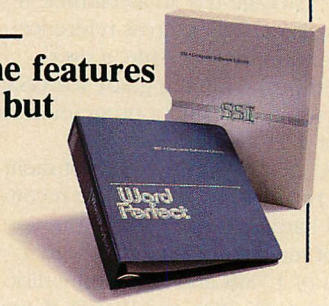
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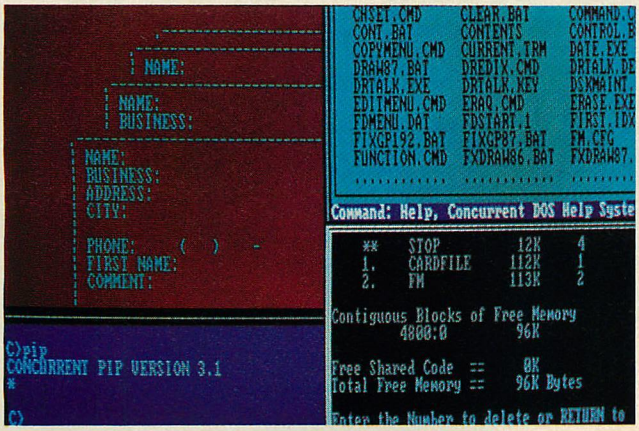
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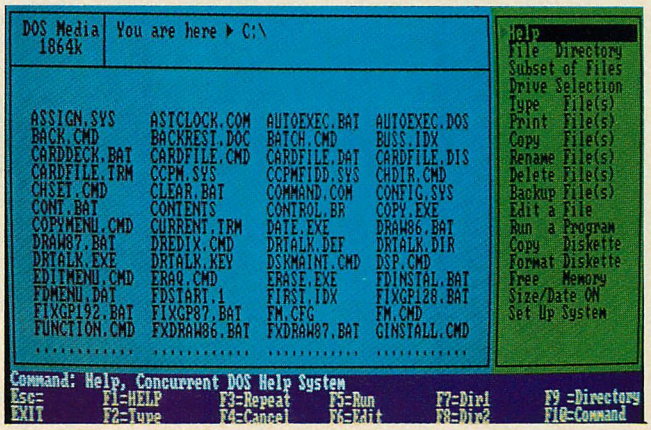
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PHOTO 1: *Four Tiled Windows*



Windows may be overlapped, displaying the entire active window and as much of the other windows as possible.

PHOTO 2: *The File Manager Menu Screen*



Commands can be typed on a status line on the FM menu screen, or the menu screen can be exited for command entry.

tively add-on hardware runs with C/PC-DOS. A list of popular third-party IBM DOS software was also tested with C/PC-DOS. The results of these tests showed that some IBM DOS features are absent, some hardware incompatibilities exist, and a large set of IBM DOS software is not compatible with C/PC-DOS.

Limited hardware compatibility testing produced conflicting results. An AST Six-Pak Plus board and supporting software worked perfectly. Hayes Smartmodem models 1200 and 1200B worked without adjustment. However, neither the Tecmar Graphics Master nor the new IBM Enhanced Graphics Adapter board worked with C/PC-DOS; rebooting was necessary when a display window was assigned to the color monitor driven by the new IBM color card.

Three major types of software incompatibility exist between C/PC-DOS and IBM DOS: video problems, the use of IBM DOS 2.0 function calls, and specific program checks for correct IBM DOS version (C/PC-DOS reports 1.1).

The use of the function keys F1 through F5 for editing is not supported by C/PC-DOS. These keys make keyboard entry easier by allowing the most recent command line to be edited and reissued. Alternatively, the function keys are easily programmed under C/PC-DOS with a menu-driven program called FUNCTION.

A command that changes the current directory through two levels of subdirectories, such as CD C:\SUB1\SUB2, is illegal with C/PC-DOS; instead, two commands—CD SUB1 followed by CD SUB2—must be used. The diskette drive on an IBM PC/XT or single-diskette-drive PC cannot be used as drive B:, which makes diskette copying on these machines difficult.

A minor incompatibility exists in standard device names, which can be different in C/PC-DOS than they are in IBM DOS. For example, serial ports are COM1: and COM2: under IBM DOS and Port 0 and Port 1 under C/PC-DOS.

BASICA.COM shows a unique type of incompatibility. Because of the way that BASICA directly takes control of all PC hardware, it cannot run in more than one window at the same time. If it happens, the user will know. Reboot.

Video problems, if present, are not fatal. C/PC-DOS supports IBM DOS programs that use IBM DOS video function calls, IBM BIOS calls, and direct access to video hardware or video memory. However, the four windows of C/PC-DOS become corrupted when an individual IBM DOS program assumes it can output anywhere on the display. If the program writes outside the boundaries of its assigned C/PC-DOS display window when the window is not active or is less than a full screen in size, another window is violated. C/PC-DOS minimizes this problem by permitting all screens to be redrawn, so that the current window and displays behind each window can be restored.

Window boundary problems are one reason C/PC-DOS includes the command SUSPEND; it suspends the execution of any tasks that are not in the active window. Suspension of these tasks prevents corruption of the display.

A list of IBM DOS programs tested under C/PC-DOS is provided in table 1. Note that most programs that were originally developed under IBM DOS 2.0 or later do not work, because of the use of IBM DOS 2.0 function calls that kill C/PC-DOS. Digital Research should have prevented this catastrophic failure by causing the program to display an error message and to terminate any program that executes an illegal function call—a much better result than a dead machine. In any case, most old versions (1.1) of IBM DOS programs should run on C/PC-DOS, but most programs that were developed after IBM DOS 2.0 probably will not.

MULTITASKING

Multitasking is not new to the CP/M family of operating systems that run on the IBM PC. The first Digital Research operating system with multitasking was Concurrent CP/M-86, (see "CCP/M-86," Don Awalt, *PC Tech Journal*, March 1984, p. 64). Shortly thereafter, CCP/M-86 with Windows was introduced, followed last fall by C/PC-DOS.

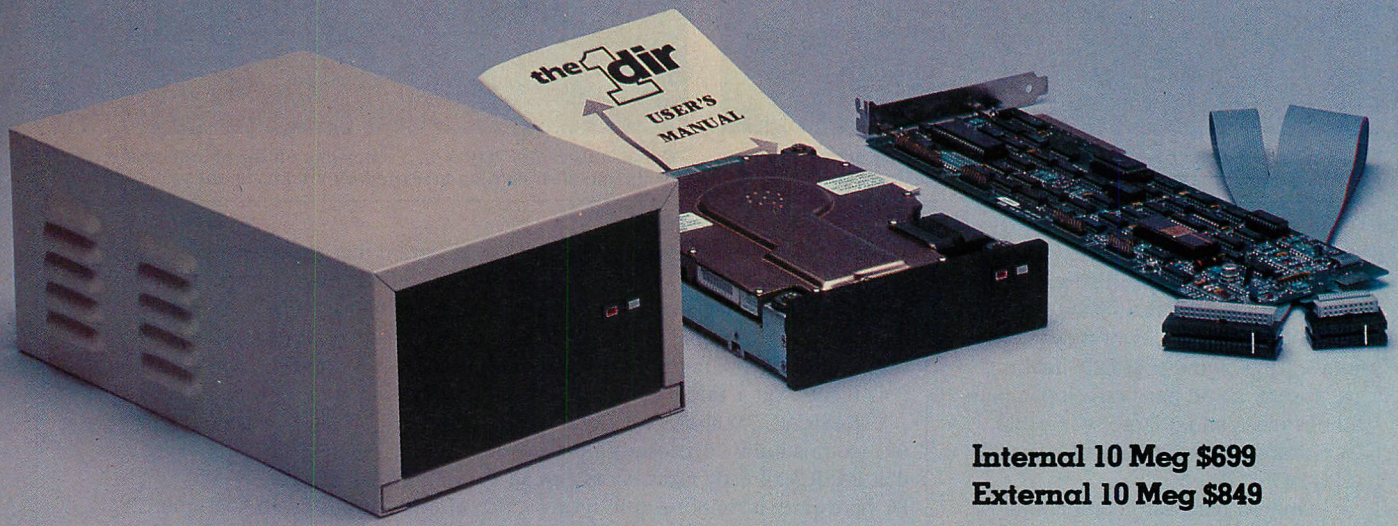
The objective of multitasking is to permit the simultaneous execution of as many as four different programs per user (six in a multiuser system). These different programs, or tasks, are referred to as *virtual terminals* in C/PC-DOS terminology.

Multitasking takes advantage of the time the computer "waits," such as when it waits for I/O to complete or for keystrokes to be entered. During these waiting periods, which may last only milliseconds, other programs are given the chance to run. Control is given to programs on a round-robin basis; tasks are switched whenever the current task must wait for I/O or when its maximum time slice has expired.

The IBM PC display is switched to each of the different virtual terminals by pressing Ctr1-1, Ctr1-2, Ctr1-3, or Ctr1-4; the numbers are entered from the numeric keypad. FUNCTION can be used to redefine the keys used to switch virtual terminals if these key definitions conflict with an IBM DOS program.

A window will be displayed somewhere on the screen when its virtual

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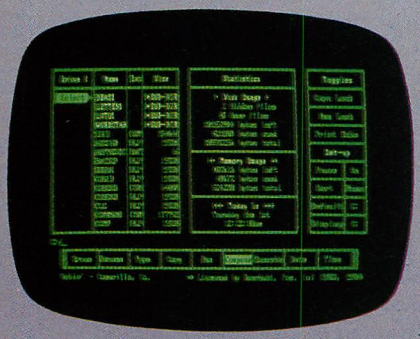


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terminal is activated. Each window can be configured using WMENU to control the size, color, and position of the window on the screen. The sizes of the four windows can be defined so that all are simultaneously displayed on the screen in either an overlapped or a tiled effect (all four windows appear in their entirety.) If the windows are overlapped, the entire active window is displayed, and as much of the other three windows will be displayed as possible. Photo 1 shows the screen partitioned into four tiled windows.

Each virtual terminal has a start-up batch file (similar to AUTOEXEC.BAT under IBM DOS) so that a different recipe of programs can be defined to run in each window when the PC is booted.

The SUSPEND command mentioned earlier, which permits or prevents tasks other than the active task from executing, can be used to speed up one task at the expense of others, as well as to minimize the impact of a program that does not fully obey the window boundaries of C/PC-DOS.

Adding multitasking functionality to an operating system involves adding some related features as well. The resources of the PC—files, printers, and displays—must be protected from inadvertent and simultaneous use by multiple tasks. Password protection and several programs—USER, PRINTER, and PRINTMGR—are provided with C/PC-DOS to manage these resources.

USER selects one of sixteen user numbers as the current user. CCP/M-86 files and printers can be defined to be the sole property of a particular user, preventing their use by others. Special authority is given to USER number 0, the system user. USER 0 can access any files and use any printers in the system.

PRINTER is used to display or assign a specific printer to a particular window. Although PRINTER can dedicate one of five system printers (three on parallel ports, two on serial ports) to one window (or task), all windows can be configured to use the same printer.

PRINTMGR manages simultaneous printing from all windows. PRINTMGR maintains a job queue of file specifications that are to be printed for each window, preventing printer problems resulting from competing tasks.

C/PC-DOS provides password protection. The SET command defines for each file the operations that will require password entry. Four different options for the set of operations requiring password control are available: reading, copying, writing, deleting, or renaming; writing, deleting, or renaming; deleting or renaming; and unlimited file operations. SET supports wildcard file specifiers, so a family of files can have the same password attributes.

USER and password protection, two of the tools that provide file protection when multiple tasks are operating concurrently, cannot be used with files on IBM DOS media. Extreme care must be taken when such files are in use, because C/PC-DOS permits multitasking corruption of IBM DOS files.

Memory becomes a scarce resource when multitasking is in use. Because C/PC-DOS uses approximately 156KB of memory, it is difficult to find more than two tasks that can run simultaneously in the minimum 256KB configuration. 640KB of RAM is recommended for any PC with C/PC-DOS, although even having maximum memory will not guarantee that four medium-to-large-size applications will be able to run concurrently.

FIGURE 1: *Multiuser Performance Benchmarks*

OPERATION	SPEED IN SECONDS	
	PC	TERMINAL
Type		
Single user	79	362
Multiuser	99	362
Masm		
Single user	45	45
Multiuser	147	147
Copy		
Single user	48	46
Multiuser	95	95

These benchmark results show that the amount of performance degradation from multiuser activities depends on the particular type of operation that is performed.

MULTIUSER CAPABILITY

C/PC-DOS supports two user terminals connected to the serial ports. The terminals can be IBM PCs, other PCs, or "dumb" ASCII terminals (DEC VT100 or VT220, Televideo 910 or 920, IBM 3101, etc.) Multiuser terminals are connected to the host PC through a direct RS-232 connection or a modem-equipped line. Full use of the multiuser capability supported by C/PC-DOS enables six tasks to operate concurrently. When the link between the terminal and the host PC is established, the terminal screen is identical to one full C/PC-DOS window.

The first step in setting up a C/PC-DOS multiuser terminal is the installation process. One hour and the help of two experts was required to establish a communications link between the terminal and a PC over a modem—it was more difficult than expected.

The problem was with the documentation: it did not address many of the questions that arose during the installation process. It did not approach the clarity of the section describing the installation of single-user C/PC-DOS. A sample of C/PC-DOS installation documentation follows:

> To load Concurrent in a computer with two floppy-disk drives, first insert the Startup Disk into Drive A and Utility Disk 1 into Drive B with the labels facing up. Next, close the drive doors and turn the power on.

Very complete, with no ambiguity. Compare that with the following sample of multiuser documentation:

> Decide what devices you are going to connect to the serial ports. Find out what the devices' data-transfer characteristics are. Refer to the manuals provided with these devices, and do any configuration they require first. Then run SETPORT and select characteristics for each port that correspond to the characteristics of the devices to be connected.

Data-transfer characteristics? Configuration? Tough questions for someone who has only just booted C/PC-DOS.

I never did get a direct, non-modem link to work. In spite of consultation with Digital Research, it never became clear whether the culprit was a software bug or an error of mine. The line appeared to be all right, because the same RS-232 cable was successfully used to link an IBM DOS-based PC running Crosstalk XVI with a C/PC-DOS-based PC running DRTALK. My contact at DRI had not used a PC as the terminal, but that should not have mattered. My conclusion? *Caveat emptor.*

Several restrictions apply only to use of the system at the terminal. Only one task can be run at a time, so there is no window switching at the terminal. Programs that require function keys for input cannot be used. Programs accessing video hardware directly cannot be run at a terminal, either, as they can

cause the terminal to lock up and become unusable. Also, the status line at the bottom of the C/PC-DOS screen, which shows the currently active program, the disk drives being used, the printers available, and the system time, does not display at the terminal.

C/PC-DOS provides a command, STOP, that terminates any of the tasks running on the PC. Ending a task frees the memory for use with other tasks.

One user is not protected from other users when IBM DOS media is being used. Password protection and the USER command cannot be used. The current definitions of the floating disks and the system disk are shared between users, with potentially disastrous results. For example, assume that user A sets **n:=c:\scratch** and prepares to delete all the files in that subdirectory. User B sets **n:=c:** for his work; when user A does a **DEL n:*.***, all the files in the root directory, including all of C/PC-DOS, are deleted.

Another important feature of any multiuser system is speed. If it is fast, perhaps other shortcomings are bearable. Unfortunately, however, the performance of C/PC-DOS is a considerable drawback to its usefulness.

Of course, there are reasons for C/PC-DOS's sluggish pace. Multiuser and multitasking capabilities require a considerable amount of overhead to manage separate tasks and their environments. In addition, C/PC-DOS's interface between IBM DOS and IBM DOS programs further burdens the system.

The execution of C/PC-DOS equivalents of internal IBM DOS commands is slow. IBM DOS's CHDIR command, like all internal IBM DOS commands, is memory-resident and can be executed quickly. Under C/PC-DOS, CHDIR must be loaded from a disk and executed in a heavily loaded C/PC-DOS system.

Software benchmarks provided further testament to the poor performance of C/PC-DOS. The first test uses dBASE II to modify a record and reindex the entire database, which consists of 254 records, each 225 bytes long, with 13 fields of varying size and 1 key. This particular task, when run under IBM DOS, took 33 seconds; run under C/PC-DOS as a single task, it took 45 seconds; run under C/PC-DOS as two concurrent tasks, it took 116 seconds.

C/PC-DOS with a single task running was 36 percent slower than IBM DOS; note also that the two tasks run concurrently under C/PC-DOS take 26 seconds longer than if they were run sequentially (116 seconds versus two times 45 seconds). Thus, a 29-percent performance penalty results from multitasking. The same two tasks run sequentially with IBM DOS take 66 seconds—concurrent C/PC-DOS is 76 percent slower than sequential IBM DOS. Other tests yielded similar results.

TABLE 2: *C/PC-DOS Commands*

NAME	PURPOSE
8087	Indicates to Concurrent that a .COM or .EXE program uses an 8087 coprocessor
ADDMEM	Increases the memory allocation of programs with the .EXE file extension
BACK	Backs up the files on hard-disk partitions to floppy disks
BATCH	Executes the commands in a file that has a .BAT file extension
CARDFILE	Stores and retrieves names, addresses, phone numbers, and comments
CHDIR	Same as IBM DOS CHDIR command
CHSET	Changes the command header of programs with the .CMD file extension
COMSIZE	Sets the amount of memory allocated to programs with the .COM file extension
COPY	Copies files between directories and devices
COPYMENU	Copies one or more menus from one file to another
DATE	Displays and changes the date
DEL	Erases files
DELQ	DEL with query
DIR	Same as IBM DOS DIR command
DREDIX	Invokes text editor similar to IBM DOS EDLIN
DRTALK	Communications utility program identical to PC-TALK III
DSKMAINT	Performs floppy disk format, verify, and copy functions
EDITMENU	Creates, modifies, and deletes menus
ERAQ	Same as DELQ
ERASE	Same as DEL
FM	Invokes File Manager that permits selection of commands from a series of menus
FUNCTION	Assigns function-key commands and window-switching keys
HDMAINT	Similar to IBM DOS FDISK
HELP	Explains Concurrent C/PC-DOS commands

An additional set of tests was run to determine the performance impact of multiuser operations. Three multiuser tests were performed: TYPEing a file to the PC and terminal displays, performing an assembly of a file using MASM, and doing a file COPY of the contents of a subdirectory. The results of these tests are shown in figure 1.

The first test was TYPEing a 43,264-byte file. The terminal was running over a 1200-baud modem, and the communications time was the major cause of the slow TYPE speed at the terminal. Although a file of this size takes 360 seconds to transmit over a 1200-baud line, and other processing time appears to be only two seconds, the transmission of the file and the other processing are being done concurrently. Ample time is spent waiting for transmission to complete, providing an opportunity for multitasking C/PC-DOS to be efficient.

If a direct 9600-baud link is used, the file transmission time is eight times faster—the transmission takes about 45 seconds. There is less time available to overlap communications transmission and other overhead, so TYPE speed with a 9600-baud line should be comparable to the times shown at the host.

The PC host runs slower if a terminal-resident TYPE task is running concurrently (99 seconds compared to 79 seconds for a task running alone—a 25-percent performance degradation), whereas the terminal takes the same amount of time to run the task (362 seconds) whether that task is running concurrently or alone.

TYPEing at the terminal is not slowed by host tasks because C/PC-DOS has ample time to process other tasks

NAME	PURPOSE
INITDIR	Formats CCP/M-86 media to allow time and date stamping (which is always done on IBM DOS media)
LOADCCPM	Loads C/PC-DOS from an IBM DOS partition without changing the existing IBM DOS operating system files
MKDIR	Same as IBM DOS MKDIR command
ORDER	Changes the command file search order based on extension
PIP	Copies files between directories and devices
PRINTER	Changes or displays the current printer number
PRINTMGR	Controls printing of files between users and tasks
REN	Renames files
REST	Restores files to hard-disk partitions from a set of floppy disks
RMDIR	Same as IBM DOS RMDIR command
RUNMENU	Runs a menu program
SDIR	Displays directory and file status information
SET	Sets files and drive-related attributes (time and date stamping)
SETPORT	Configures serial ports
SETUP	Modifies C/PC-DOS default system characteristics
SHOW	Displays information about disk drives
STOP	Displays memory allocation and terminates programs
SUSPEND	Suspends .EXE and .COM programs when their windows are switched out
SYSDISK	Displays and changes the current systems disk
TIME	Displays and changes the time of day
TYPE	Displays the contents of a text file
USER	Changes the directory user number on CCP/M-86 media
WINDOW	Shows and modifies window characteristics
WMENU	Changes window configuration

Most C/PC-DOS commands are similar to those in Concurrent CP/M-86 with Windows.

while waiting for the communications transmission to the terminal to complete. TYPEing at the host, however, *is* slowed by TYPEing tasks at the terminal; because no delays occur when TYPEing a file at the PC display, and therefore C/PC-DOS must force a wait on this task to process other tasks.

Figure 1 shows how long it took to assemble a 10,682-byte (10KB) file using MASM. MASM is an efficient use of a terminal in multiuser mode; the terminal and the PC assembly times were identical. The impact of a 1200-baud line is minimal in this test, because MASM is a CPU-intensive program. This test also showed that the performance degradation when two tasks are run is staggering (147 seconds for concurrent use versus two times 45 seconds for sequential use—a difference of 57 seconds); concurrent assemblies take 63 percent longer than consecutive assemblies with C/PC-DOS.

COPY speed is comparable at the terminal and the PC. The multitasking penalty is negligible (although multitasking COPYing is not faster than consecutive COPYing). Multitasking of two COPYing procedures is fairly efficient because C/PC-DOS can take advantage of many I/O operations to schedule the inactive COPY program to run.

Two other tests had noteworthy results. First, PIP was used to transfer files between subdirectories; the results were comparable to COPY. Second, PRINTing a file took the same amount of time at the terminal and the host PC, because the terminal is used only to start the job at the host PC.

When multiple tasks are being run, consecutive execution is usually faster than concurrent operation. When multiple users are required, memory-intensive functions can be run at the same speed at the terminal and host PC, although the system will degrade as a result of multitasking. Tasks requiring a lot of data to be transmitted to the terminal for display should not be run because of the slow transmittal pace.

C/PC-DOS is the newest version of CCP/M-86 for the IBM PC, and some of its software deserves examination. Table 2 lists all the commands included.

C/PC-DOS is similar to Concurrent CP/M-86 with Windows: function-call usage is unchanged, and the optional Programmer's Pak has not changed with the introduction of C/PC-DOS.

One difference between C/PC-DOS and prior CCP/M-86 releases is that the documentation provided with C/PC-DOS does not include the Programmer's Guide. This guide is similar in content to the IBM DOS *Technical Reference* manual and is a requirement for any programming with C/PC-DOS.

C/PC-DOS has a well-thought-out user interface. The use of color and menus makes working with C/PC-DOS much easier than attempting to use UNIX or PICK for the first time. Menus enable users to run programs without having to remember command sequences, and menus within programs make it easy to select options. Photo 2 shows the File Manager menu screen.

For the more experienced user, C/PC-DOS supports two types of command-entry mode: commands can be typed on a status line on the File Manager (FM) menu screen, or the FM menu screen can be exited entirely for command entry. Command mode provides quick entry for experts who wish to avoid the burden of a menu series.

Several programs are bundled with C/PC-DOS that provide functions not supplied with IBM DOS. The first is CARDFILE, a small database program that provides preformatted "index cards" with fixed field definitions. Each card has fields labeled NAME, ADDRESS, CITY, STATE, ZIP, PHONE, FIRST NAME, and COMMENTS. Cards can be sorted, searched, accessed, or printed based on field values.

CARDFILE provides seven commands: COPY/UPDT, DELETE, INSERT, PRINT, SCROLL, SEARCH, and UPDATE. COPY/UPDT makes an exact copy of a card for editing. This is a useful feature when a number of cards with identical fields are being added; COPY/UPDT is used to copy the previous card, and additional information is then added. UPDATE enables modification of the card currently being displayed.

DELETE deletes the topmost card from the "deck" or file. The file looks like a deck of index cards when displayed, because the top card is displayed completely, the second card is

partially hidden, with only NAME and BUSINESS showing, and the third card shows only NAME. When the top card is DELETEd, all remaining cards in the deck move up into display position.

INSERT displays an empty card for entering information. As each new card is INSERTed by the user, it is placed in the deck in alphabetical order.

SCROLL can be used to review all existing cards. The cards are displayed continuously, using the three-card display format. When the end of the file is reached, the first card is displayed, and scrolling continues. The cards are displayed in alphabetical order by NAME.

Cards in the file can be PRINTed in display format or in a format suitable for a mailing label. All cards or a selection of cards can be printed.

Cards can be SEARCHed by selecting a NAME, PHONE, FIRST NAME, or BUSINESS value. If a card with the desired value is found, that card is displayed on top and it is available for UPDATEs, DELETEs, or COPYs.

C/PC-DOS also provides tools for creating, editing, copying, and using menus. With EDITMENU, COPYMENU, and RUNMENU, existing system menus can be modified or new menus created. EDITMENU uses text colors, and borders to produce a menu of functions that can be selected through the function keys. Reverse video, underlining (monochrome displays only), brightness, and blinking can also be used while creating menus. COPYMENU copies and stores menus in a condensed form, and RUNMENU executes the finished menu file.

Another significant software product that is included with concurrent PC-DOS is DRTALK. Very few differences exist between it and the IBM DOS version of PC-TALK III.

The DRTALK/PC-TALK package is comprehensive. Communications parameters, file transfers, data transfer to disk or printer, phone-number directories, function-key assignment, pacing, filtering, binary transmission, and XMODEM transmission are just some of the features of this package. Table 3 lists all of the DRTALK commands.

MDISK provides up to 256KB of RAM-disk capability with C/PC-DOS. C/PC-DOS does not provide more memory for the RAM disk because so much is required to run four concurrent programs. MDISK provides a substitute for IBM DOS RAM-disk device drivers that might not work with C/PC-DOS.

A final program worthy of note is HELP, which is absent in IBM DOS. Most of the major commands are explained in HELP, and the descriptions are sometimes identical to documentation found in the *User's Guide*.

TABLE 3: *DRTALK Program Commands*

COMMAND	DESCRIPTION
ALT-E	Toggles between full and half duplex
SHIFT-PRTSC	Prints current screen contents
CTRL-PRTSC	Simultaneously prints all console output to the printer
ALT-R	Starts or stops receiving files from a remote computer
ALT-T	Starts or stops transmitting files from a remote computer
ALT-V	Displays a file saved on disk
ALT-Y	Deletes a disk file
ALT-D	Permits creation, modification, storing, and access to up to 60 phone numbers, this dialing directory permits auto-dialing and easy phone number retrieval
ALT-Q	Redials the last number dialed
ALT-M	Sends status messages as part of transmit/receive functions
ALT-P	Changes communications parameters
ALT-F	Permits temporary or permanent changes to program defaults
ALT-K	Assigns up to 40-character commands to the ten function keys
ALT-=	Assigns commands to Alt-0 through Alt-9
ALT-S	Writes screen contents to the file SCRNDUMP.PCT on the default drive
ALT-L	Changes the default drive assignment
ALT-W	Sets an optional width alarm for keyboard input
ALT-Z	Displays elapsed time for the current call
ALT-C	Clears the screen
ALT-O	Permits restarting transmission manually, when the remote computer has stopped transmission with an XOFF signal
ALT-X	Exits the program
CTRL-END	Sends Break signal to the remote computer
HOME	Displays a summary of DRTALK commands

DRTALK is a comprehensive program that is virtually identical to the IBM DOS version of PC-TALK III, by Andrew Fluegelman. PC-TALK has an additional freeware notice.

Three major weaknesses plague C/PC-DOS. The first is performance; no throughput advantage is realized by the multiuser or multitasking capabilities. Benchmarks prove that programs run faster consecutively than concurrently.

The second major weakness is the absence of pathname support. Digital Research plans an upgrade of C/PC-DOS in April, 1985, that will fully support IBM DOS 2.1, including pathnames. Many of the more recent IBM DOS programs should be compatible with C/PC-DOS when that happens.

The third major weakness is the lack of security with IBM DOS disk media. Files on such disks are virtually unprotected against corruption from multitasking or multiple users. A second upgrade to C/PC-DOS, which Digital Research plans to release in the summer of 1985, will support IBM DOS 3.0 and will purportedly provide the necessary file and resource protection.

For the time being, C/PC-DOS 3.2 is recommended for those users with work habits that require concurrent PC activities, but only if performance is not an immediate concern.

C/PC-DOS also might be useful for those who require limited multiuser capability, if the terminal usage is frequent but not lengthy. Finally, it might be attractive to users who wish to run both IBM DOS and CCP/M-86 programs or who use only Concurrent CP/M-86 on the PC. Such users can capitalize on all the IBM DOS software that is not available in CCP/M-86 versions.

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Don Awalt is in systems engineering management at EMC Controls in Hunt Valley, MD. He did a review of Concurrent CP/M-86 in the March 1983 issue of PC Tech Journal.



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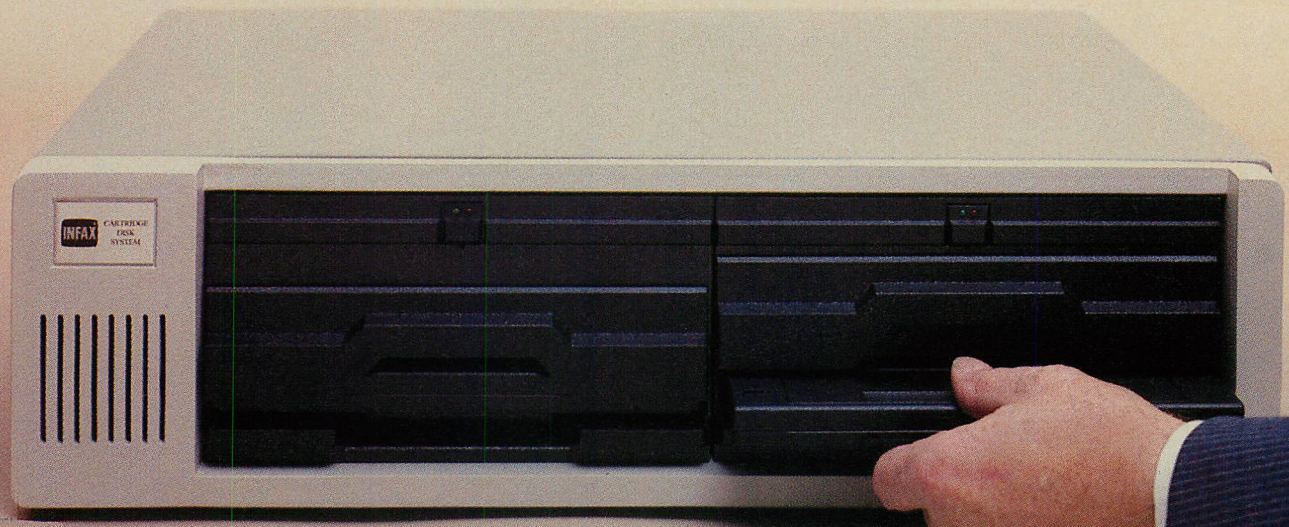
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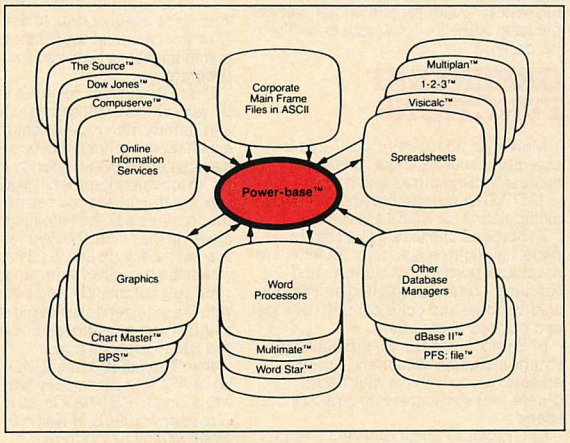
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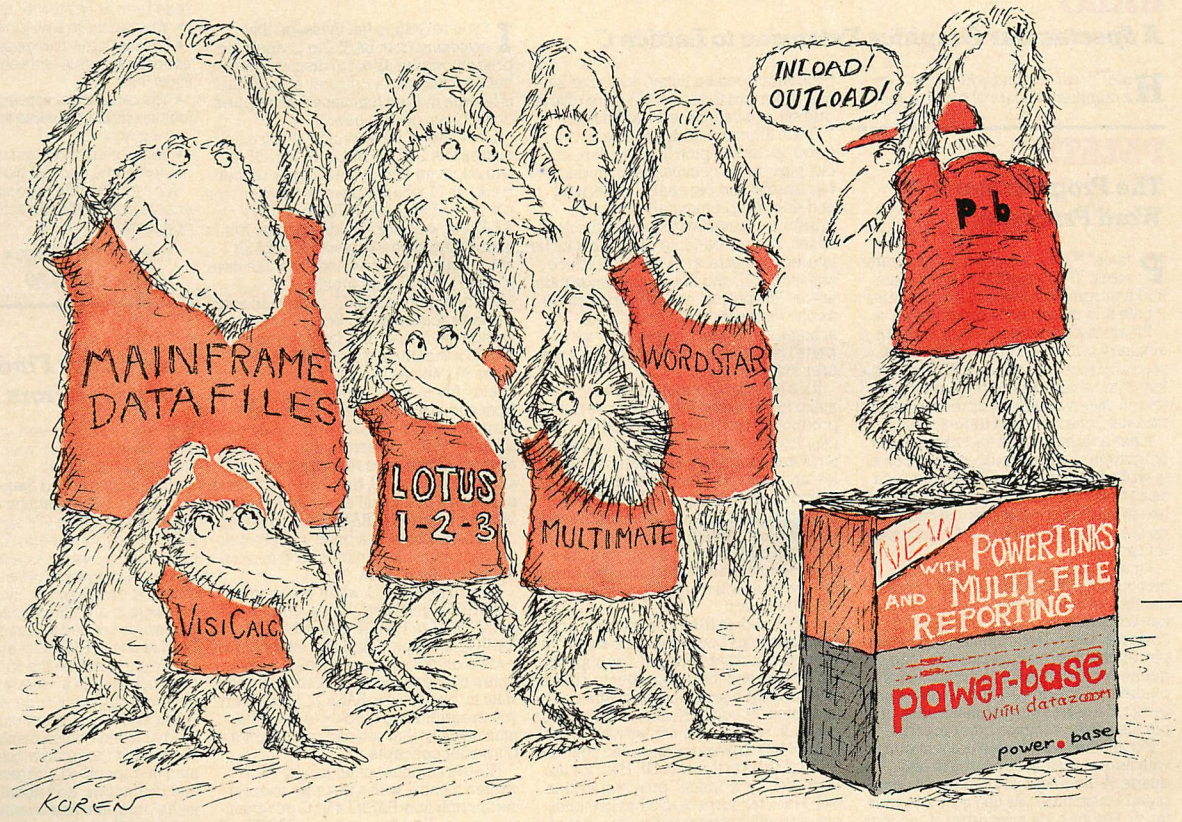


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PC BRAND™'s CRAFTSMAN™ TOOLS FOR C PROFESSIONALS

LIBRARIES: *Hundreds of Functions for Fast Programming*

C is a bare-bones language. It does not have built-in (machine dependent) functions for printing or floating point math or string manipulation. That's why it's so portable. That's also why libraries of pre-written functions are such big sellers: bullet-proof routines your application can effortlessly call to get the job done.

GREENLEAF FUNCTIONS

More than 200 functions in C and/or assembler source, and a 200 page manual with examples and demos.

32 DOS extensions: file and directory manipulation for DOS 1.1 and 2.0.

23 Screen Functions: Select mode, page, monochrome or color, palette; cursor shape, positioning; clearing and scrolling; character reading and writing with attribute and color control; pixel get and put; read light pen.

60 String Functions: Manipulation of strings including center and justify; efficient list operations which add, delete, and sort pointers to strings for top speed.

50 Graphics Functions: Primitives to access all graphics; typeface, formatting, and forms control for IBM Graphics Printer.,

Plus keyboard status and function key assignment, time and date algorithms . . .we could go on!

Product Code: S0770 # Our Price:
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GREENLEAF COMMUNICATIONS NEW!

Want your application to communicate with other users or remote date bases? Now you can build asynchronous communications right into your C programs!

Over 60 functions set up an interrupt driven scheme with separate transmit and receive ring buffers (characters are simultaneously loaded at one end and transmitted from the other, or vice versa) for an arbitrary number of ports. Interrupt control means you can download a record, then halt the incoming stream to file it, display it, let the user tamper with it, send it back up line. It all happens within the context of *your* program, using your user commands, and does away with the sidestep to the separate communications software (and its semantics) you had to use until now.

The Greenleaf Comm Library supports ASCII or binary, any parity, any word length, 8250 UARTs, all four Lattice C memory models, Hayes 300, 1200, 1200B and other modems.

Its 80-page manual has examples of each function, discusses asynchronous communications, and both the library and demo programs come with source (a mix of C and assembler)!

Product Code: S0750 # Our Price:
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LATTICE C-FOOD SMORGASBORD

Decimal Arithmetic: Trigonometric, logarithmic functions, powers, conversion to strings, BCD operations for numbers up to 16 significant digits.

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Terminal Independence Package lets you move programs to computers with other types of terminals.

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Quite a treasure. So cost effective that after using only a couple of functions you'll be saving a bundle compared to writing your own. (It's true; how much do you cost per day?). So why not go for the whole bundle!

HALO

A Spectacular Graphics Extension to Lattice C

Halo™ will astound you. It provides a complete library of graphic functions which can be linked with your Lattice programs to create full-color charts, graphs, simulations, even animation.

Over 100 commands are at your disposal, including plot, line, arc, box, circle, plus single commands to produce bar graphs and pie charts. Pattern-fill and dithering commands give your graphics impressive texture and color mixes, rubber-banding draws shapes for interactive users, area moves produce animation, fill and flood commands paint areas. The newest version allows you to define your own world coordinate scheme, divide the screen into "viewports" (windows), and scale graphic figures automatically.

It's a long list of capabilities which make for an extraordinarily powerful product. In fact, Halo is so good that manufacturers of graphics boards and systems are adopting it as a standard graphics language. So it can bridge your application to other systems. CAD-CAM developers, especially, have embraced its device-independent approach for maximal portability. Halo offers a dazzling demonstration that function library architecture will tremendously enhance your firepower.

You'll need an IBM monochrome or color graphics board for our standard version, but other versions now support ten boards and their equivalents. Halo is sold in a one board, one language configuration (special pricing for multiples), but each version now comes with a multitude of I/O drivers for mice and printers.

Tip: Ask us to throw in Dr. Halo for an extra $95. It's a "paint" program written with Halo, far surpasses other pretenders, and will open up realms of creativity. Brilliant beyond belief.

Product Code: S0300 Our Price:
List Price: **$200.00** **$125.00**

PMATE

The Programmer's Word Processor

Pmate™ was designed for programmers. We'll wager that you cannot find a programmer who has discovered Pmate and moved on to something else.

Pmate is a full screen editor with ten auxiliary buffers for squirreling away pieces of text until needed. It uses single key commands to move the cursor, or text, or insert or delete, or rescue several thousand characters of deleted text.

It has a format mode for tab setting or wraparound and shaping when it's time to write documentation. Pmate lets you assign chains of commands or strings of text to single keys: a keystroke could set up the entire shell of a new C function, for example.

Pmate has variables, if-then statements, loops. It calculates, and converts decimal to hex to binary and back. You can write compact programs (called "macros") to delete comments, for example, or check syntax, or process long sequences of commands. Macros can alphabetize lists, do row and column math, perform a series of operations on multiple files, even summon other macros.

Put another way, Pmate is a text editor with its own built-in interpretive language. A language you can use to completely customize this text editor to your fancy. Possibly the most artful, ingenious program you have ever seen.

Product Code: S0600 # Our Price:
List Price: **$225.00** **$175.00**

BASIC_C

Use Your Knowledge of BASIC to Learn C

If you're getting the message that switching from BASIC to C would be prudent, you're about to discover that it's back to basics of a different sort. BASIC is fat with hidden functions that stripped down C just doesn't have.

Gone are all those handy string manipulators like LEFT$, MID$, STRING$, etc. (although our library offerings add them back). In C, when you reach for even simple invocations like INPUT or PRINT A$,X% — well, sorry to disappoint, but underlying such expressions in BASIC are bulging macros which C cannot have if it is to keep its slim profile.

But now comes BASIC_C and all your old favorites are back. Someone has written the full set of C functions to mimic BASIC's vocabulary, from ABS to WRITE. Over 80 routines to open and close files, "field" file buffers, convert their contents from and to strings (the CV? and MK? series), peek and poke, print using, clear screen, "instr", on error goto. . . they're all there. Some have reworked names and syntax to suit C, but all are written as one-to-one functional equivalents to the familiar features of BASIC. And they are documented one to a page in alphabetical sequence like the Microsoft manual for added familiarity.

So with BASIC_C, when you're thinking INPUT, go ahead. Use it. Or LPRINT or LOCATE or INKEY. But without BASIC_C, you will find that every line of code plunges you back in the C texts to figure out how to write it. Someday you'll want to, but for now, BASIC_C will start you programming quickly at the statement level so that you can concentrate on C's larger concepts.

There's a bonus: an unusually well-written manual with a first rate chapter comparing how BASIC and C go about their tasks. Without question, BASIC_C will ease your transition to C.

Product Code: S0350 # Our Price:
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LATTICE WINDOW

All Your Applications Could Have Windows!

Windows are no *gimmick*. Ask any user of a windowed product.

But how do you add this technique to your applications without disappearing for several months of R&D?

With Lattice Window,™ that's how. One of those rare programming tools which will change the way you think of program design. Here's how:

Lattice Window takes over all screen management. It is an extensive set of object code functions which you merely call from your C program.

Think of a window as a screen of flexible size. You can tell Lattice Window to open and close many such virtual screens. Up to 255 at a time, each from 1x1 to 255x255 bytes. Then tell "Window" to display any portion of these virtual screens on the physical screen — as many as fit. Tell "Window" to place them wherever you want, overlapping and overlaying at will.

Windows no longer needed may be closed. Any background area overlaid earlier (which could be corners of several windows) will pop back to the screen. Think for a moment what a programming job that technique represents.

To your program, the entered window is the *entire* screen — all row and column references are relative to the window no matter its absolute position in the screen. All scrolling occurs only within the active window. The cursor will not leave its boundaries until your program says to. Any screen window may be entered for display, data entry, whatever. *Any* virtual screen — displayed or not — may be read from or written to by your program.

- You can move a window on the screen.
- You can grow it to display more of the underlying virtual screen. Or shrink it to show less.
- You can control screen attributes (color, blinking, inverse video, etc.) of any window.
- You can direct output to either the monochrome or color board.

It's a formidable product which will add incomparable flair to your next application!

Product Code: S0800 # Our Price:
List Price: **$295.00** **$235.00**

FAST-C

This Editor Finds Compile Errors

Here's how to speed up the glacial crawl of editing your program file, running the compiler, noting errors, counting lines to find them, reloading the editor, and around again:

Re-direct Lattice C's error messages to FAST-C (via pipe or file). FAST-C puts errors and program together on the screen and gets you out of the line counting profession. It shows each error message in turn, highlights the program line which caused it, and displays the ten lines above it. FAST-C is an editor, so you can fix the error on the spot, then move on to the next, or access your entire program, add new code, etc.

You also get a library of handy debugging functions which display values, let you modify them, show contents beginning at a specified address in both hex and characters, and signal whereabouts in the program. And a multi-file scanner which can find or search and replace, using wildcards, up to 100 files at one go.

Product Code: S0250# Our Price:
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TO C OR NOT TO C IS NO LONGER THE QUESTION

BTRIEVE

Is a Pro Like You Still Doing the Filing?

If your programming still gets anywhere near the files, here's our guarantee: Nothing will increase your productivity faster than handing the filing job to a sophisticated file manager.

Btrieve™ is the best we have seen. It takes complete charge of all file indexing, reading, writing, insertion and deletion. It builds 22 commands right into the language you use in the form of functions you call to tell Btrieve what to do. The commands create, open, and close files; delete and insert records, recapturing vacated space; find records which exactly or most nearly match keys; walk files by ascending or descending key.

Btrieve's foundation is a balanced-tree indexing scheme, conceded to be the fastest search technique devised (it will find any key in a million-plus item index in four or less accesses).

Btrieve comes with interfaces to C, Pascal, BASIC, and COBOL, and the manual gives you working sample programs which demonstrate every command in all four languages. The kind of presentation which led *PC World* to exclaim "for those of us who have endured poorly written and inadequate manuals, this one is a pleasure to read."

Btrieve has mainframe specifications! A single file may have up to 24 indexes. Segments of keys may be indexed. Each index can independently accept or block duplicate keys. A record length can be up to 4090 characters; an index length 255 characters. A file may be 4 billion bytes. It can even extend a file across two drives — even two hard disks!

With Btrieve you are freed to think logically; the physical file is no longer of concern. Gone for good is all that time-wasting dickering with intricate file referencing schemes and sorting algorithms. Thinking shifts to a higher plane.

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You've Hand-Coded Your Last Data Entry Screen

Designing custom screens is intricate, time-consuming, and costly. It can make you the loser in competitive bidding. It can add weeks, even months to bringing your product to market.

But not when you use Panel™. Put Panel to work and you hire a superprogrammer for the minimum wage. Telling Panel your screen design is like using a word processor. You can add, move, copy, delete, and reshape fields with single key commands. The result? Finished C source code with field descriptors, color and highlighting, input editing by type of field, help keys, and warning messages.

Panel can also create a terminal selection program customized for your application, and gives you a utility to quickly test your finished screens. It supports user-written input verification code. It even includes a multi-key data file maintenance program which interacts with the screen you design. All the tools you need to generate code for the trickier aspects of your application.

Panel routines are powerful. Unlike so many programs which make error correction difficult once a field is departed, Panel gives the user full field-to-field movement for editing, and overtype or insert/delete within fields.

A truly superior productivity tool every developer should have.

Product Code: S0400 #* Our Price:
List Price: **$295.00** **$235.00**

*except "Tailor"

PLINK86

Size Unlimited with This Overlay Linker

Software is becoming ever more sophisticated, which means more complex programs requiring large chunks of memory. But if you use extra memory, you count on users to have expanded RAM, and forego sales to those who do not.

Plink86™ is the answer. It shoe-horns large programs into small memory. First, Plink86 acts as an alternative to DOS' Link. C encourages design of separately compiled object modules in the Microsoft relocatable format. Plink86 pulls modules together into single compiled programs. But Plink86's overlay power is what has gained it a reputation as a miracle worker. It binds into the compiled program its overlay manager which knows how to swap modules of your large linked program between disk and memory, so that each can temporarily occupy the same memory space.

Unlike other linkers, the overlay manager acts on its own, needing no calls from the source program. Instead, Plink-86's straightforward overlay description language allows you to describe your overlay structure in one place in your program — a structure permitting up to 4,095 overlays stacked 32 deep. No recompiling to re-arrange the structure!

Plink86 can even sub-divide its linked output into multiple files for programs which must span more than one disk. And it produces a symbol map for debugging with Pfix86 Plus.

PC Tech Journal calls it "the premier linker and overlay loader that's taking over at many of the programming shops around the country."

Product Code: S0500 # Our Price:
List Price: **$395.00** **$315.00**

LATTICE C

The Pre-eminent 16-bit C Compiler

C's structured approach encourages development of tight, fail-safe functions which can be counted on to return reliable results every time. Its local variables are unknown outside of functions which safeguard against accidents elsewhere. C offers powerful nested expressions which produce elegant, concise code. That's why C has become the language of choice among professionals.

Lattice C™ is the Number One C compiler. Peter Norton in *PC Magazine* (1/8/85) says, "best for systems programming . . . tight code . . . total control of what's going on . . . noticeably better than any of its competitors." After reviewing nine compilers for the PC, the *PC Tech Journal* unequivocally declared Lattice C "best for software development . . . it compiles fast and produces fast programs".

Lattice C runs on virtually any computer using an 8088 or 8086 chip, and generates code which optimizes use of the 8087 chip, if present. Create your source files with any word processor or text editor like our Pmate or ES/P for C, and Lattice C will compile them into Intel 8086 object module format for linking to other modules by DOS's Link or our Plink86.

Lattice C offers a choice of four memory models between 64K and RAM capacity for program and data to allow the program designer to choose the right combination of small memory efficiency and large memory addressability for an application.

Lattice C is a full implementation of Kernighan and Ritchie (K&R), not a subset, with some extra features, eg., variable names up to 39 characters, and nested comments.

The compiler comes with a library of I/O routines which implement under MS™-DOS most of the Unix-compatible standards described by K&R, and then goes beyond. It has a fulsome set of transcendental and Unix math functions K&R didn't think to mention, and some of Unix's most useful options such as "fork", which can pull a second program into memory without disturbing the first, branch to it, and return.

Product Code: S0100 # Our Price:
List Price: **$500.00** **$CALL**

RUN/C

REVOLUTIONARY!

A C Interpreter at Last — And it Works like BASIC!

C is contemplative, elegant. But even elitists yearn (silently) for the simpler days of throwing together code with the instant interaction of an interpreter.

The good old days are here again. We have not just a C interpreter, but one that acts like BASIC! Use RUN/C's in-line editor to create a program. RUN it, just like BASIC. If it stumbles, just LIST it, EDIT it, add lines, delete lines, RUN it again, fix it again. The simple luxury of break key interrupt is restored, and RUN/C™ even has TRON, TRACE, and a profiler which reports the number of times each program line is executed.

RUN/C's "editor" command will save a program and automatically hand it to your favorite editor for further work. Or you can use its "shell" command to summon your compiler from *within* RUN/C.

For the professional, RUN/C is ideal for rapid program development. Put up code at high speed, tinker and re-arrange, throw in test printouts, bang away at tight little sections until they're bullet proof — *then* hand them to the compiler.

RUN/C has a treasury of functions built into the interpreter — over 100 paralleling the most used functions found in Lattice C's library. Their interface is the same, so if RUN/C can run it, Lattice can compile it. Only programs calling other functions or other libraries for which you do not have source need special measures (eg., comment-out, dummy functions). Well worth it to win the productivity gains of an interpreter.

Your disk supplies a separate source code file demonstrating each of RUN/C's library functions, with a manual to match. In fact, if you are new to C, this product doubles as a superb tutorial! (Requires 256K, DOS 2.x).

Product Code: S0900 # Our Price:
$150.00

PFIX86

Advanced Dynamic and Symbolic Debuggers

Debugging programs without special tools is like fixing an automobile without lifting the hood. Pfix86™ lets you see inside your program while it is running; multiple windows show program code and data, breakpoint settings, and current register and stack contents simultaneously. You can make changes: just move the cursor into a window and type. It has an in-line assembler, so you can enter program modifications in assembler at run time.

Pfix86 Plus is an enhanced version for use with modules linked by Plink86, even those with overlays. It retains the program "symbols" otherwise lost during compiling — the names you gave to variables, functions, etc. in your source code — so you don't have to deal with hex addresses.

Both versions have dynamic trace and breakpoint setting facilities. You can then disable them without removal, activate them only upon their nth encounter, halt them when a condition is met. Everything you would want in a debugger.

List Price: Code Our Price:
Pfix86 S0550 #**$195.00** **$155.00**
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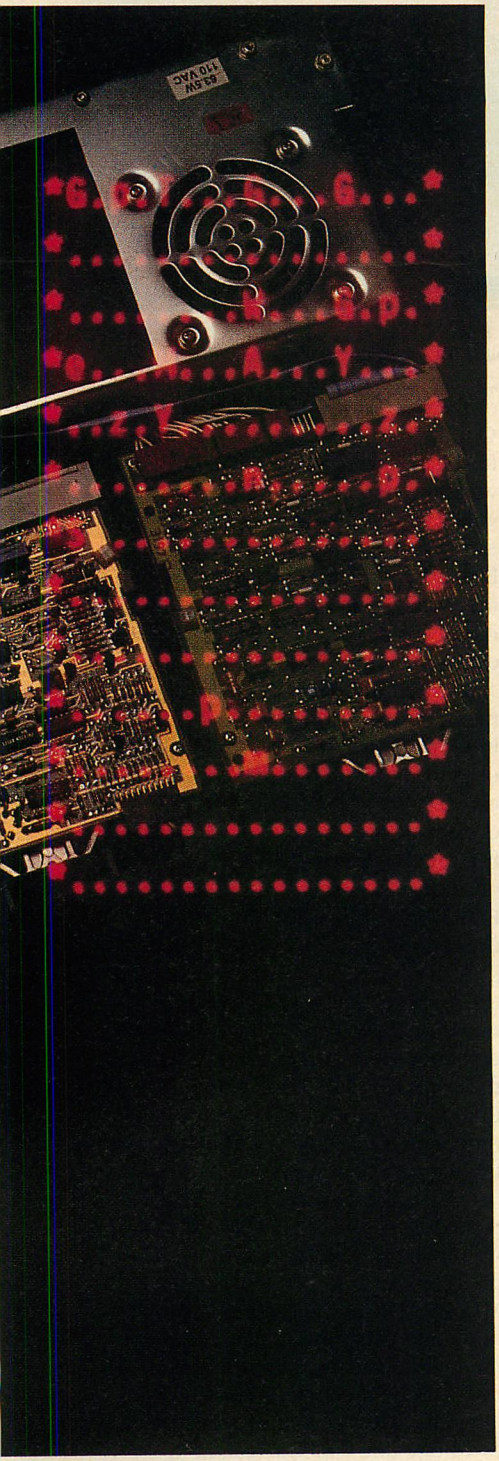
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P5

Professional Debugging



IBM's high-powered Professional Debug Facility takes off from where IBM DEBUG leaves off.



DAN DAETWYLER

IBM recently added a powerful, new debugger to its line of software. Known as the Professional Debug Facility, the debugger actually consists of two packages: the Resident Debug Tool (RDT) and the Disk Repair utility. A circuit board is included with the software for installation in an IBM PC, PC/XT, or PC/AT.

The following list offers a general comparison between the $150 Professional Debug Facility and the DEBUG.COM file that is included free of charge with the purchase of IBM's PC-DOS. These are a few of the features offered by the RDT portion of the Professional Debug Facility that are not contained in DEBUG:

- Resident facility, always available
- Full display screen, with provision for exchange with test program
- Uses "inactive" display device, if two are available
- Supports the 8087 math coprocessor, optionally
- Breaks endless loops, if included NMI card is installed
- Uses as many as four different interrupts for activation
- Provides support for EBCDIC data display

Like DEBUG, RDT permits execution of a program through single or multiple program steps; provides full trace facilities (in two formats); displays all processor registers, memory, or I/O space; and provides the normal facilities for copy, compare, find, etc. of processor memory areas. Disassembly of program displays or traces is similar to that found in DEBUG, providing a semi-symbolic representation of the program (source language instructions with hex addresses or operands).

Unlike DEBUG, RDT provides for up to 18 breakpoints that remain in place until removed by the user. It also permits establishing up to nine different environments, each with its own breakpoints and each individually controllable. It overcomes one of DEBUG's minor nuisances: RDT will let the user begin execution at a breakpoint location.

The reference manual lists the following hardware requirements: PC, PC/XT, or Portable PC with a minimum of 128KB of memory. (Although not stated in the manual, I have used the product successfully with a PC/AT.) The manual specifies a minimum of 128KB, but this is probably unreasonably small for any actual use of RDT. Since the program is resident, its memory requirements should be carefully considered. The reference manual gives these as a range of approximately 42KB to 121KB. The variance is caused by factors unique to individual use of the product. For example, 0, 4, or 16KB of memory may be needed depending on the user's decision to save and exchange the test program's screen when in RDT mode, and whether this screen consists of text or graphics. A second factor is the size of the trace buffer. This buffer can vary from 896 bytes to 65KB.

One option that IBM does not have in its list is an available slot for the nonmaskable interrupt (NMI) card. Although the card is not necessary to make excellent use of the product, it should be considered. The card is physically quite small and will fit handily in one of the short slots of the XT. It consists of a male (mostly dummy) card connector, with a push button mounted so that it will project through the rear panel of the computer. Only two lines are used from the connector. The card is a mechanical means of causing an NMI. On a PC that has all slots occupied, minimum soldering would be required to run the "I/O Ch Ck" and Gnd" lines from one of the existing cards to an external push button. Pressing the button pulls the I/O Channel Check line to ground, momentarily.

Although the RDT program can be loaded after the system is started, the

preferable method is to place the load command in the AUTOEXEC.BAT file. A full array of command line options is supported, permitting the user to control the storage required, the interrupts serviced, which display to use, and whether the applications screen is to be preserved after entry into RDT.

The manual states that "in order for RDT to work properly, it must be loaded after DOS and before any other resident extensions." However, this is not necessarily true. I habitually use a couple of poorly written resident routines that don't correctly re-establish the DOS environment when loaded in certain sequences. These routines flatly refused to run when RDT was loaded first. Everything works nicely, however, when RDT is loaded last in the sequence. The manual's method is preferred, but if other resident extensions will not work, a little experimentation may be necessary to find a sequence of loads that operates correctly.

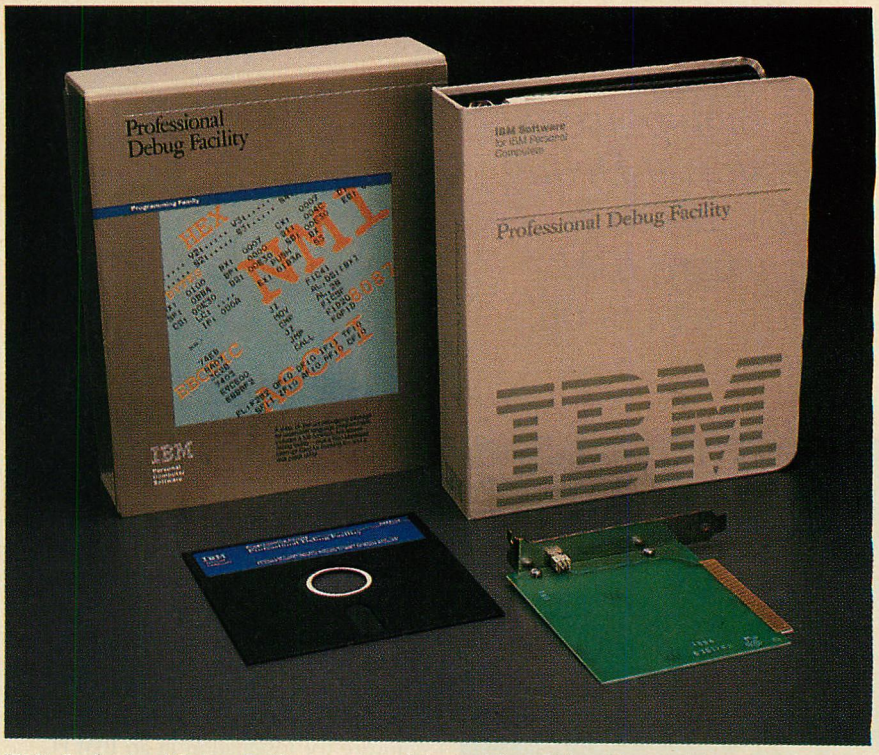
When RDT is loaded it will display a logo advertising its presence and then will return the system to DOS. It is triggered into activity by an interrupt.

While RDT is happily eating up address space, and apparently doing nothing to justify its occupancy, it is actually waiting for one of four discrete interrupts. The user controls which interrupts it monitors. When such an interrupt occurs, control is transferred to RDT. Needless to say, the user also has the capability of returning from the interrupt, so the program under test may continue without modification.

Three of the types of interrupts serviced are handled by interrupt vectors 2 and 3. To make 2 into 3, interrupt 2 may be further divided into hard and soft interrupts. Hard interrupts are associated with I/O channel check, parity errors, or pushing the button on the NMI card. A soft type 2 is initiated by execution of an INT 2 instruction or by a math coprocessor exception condition. The manual even contains information on how to avoid conflict with RDT, if the exception handler has been written for the coprocessor. Interrupt 3 is the breakpoint interrupt used by DEBUG and paralleled by RDT.

One optional interrupt can be included to provide the mechanism for avoiding the NMI card. Interrupt 5 may be assigned to RDT. This is normally the Print Screen interrupt, so the condition is triggered by holding the shift key and hitting the PrtSc key, just as when printing the display screen.

RDT can—and does—get control whenever one of these interrupts occurs. Assuming the computer is interruptible, the user may break any process at any time. With the NMI card installed the computer can be interrupted even when it is not interruptible for maskable interrupts. This feature greatly decreases the incidence of power-off, power-on breaks of process loops and interminable reboot times.



IBM's Professional Debug Facility consists of the Resident Debug Tool and the Disk Repair utility. The product also comes with a circuit board for producing a nonmaskable interrupt.

One caution if the NMI card is installed: when running the computer without RDT resident, never push the button on the card. The result will be a "Parity Test n" message, and a reboot will be necessary.

While RDT is happily eating up address space, and apparently doing nothing to justify its occupancy, it is actually waiting for one of four discrete interrupts.

MENU WINDOWS

RDT supports four different types of menus or full screen displays. Since the computer world is now very window-oriented, these menus are referred to as memory, disassemble, trace, and coprocessor windows. The headings of all of the windows are exactly the same. One item in these headings requires further explanation. The symbol D1 toward the end of the line identifies the window. The window and its contents can be saved simply by entering D2=D1 on the command line. In fact, the system may operate with as many as nine copies of windows, each with its own saved information.

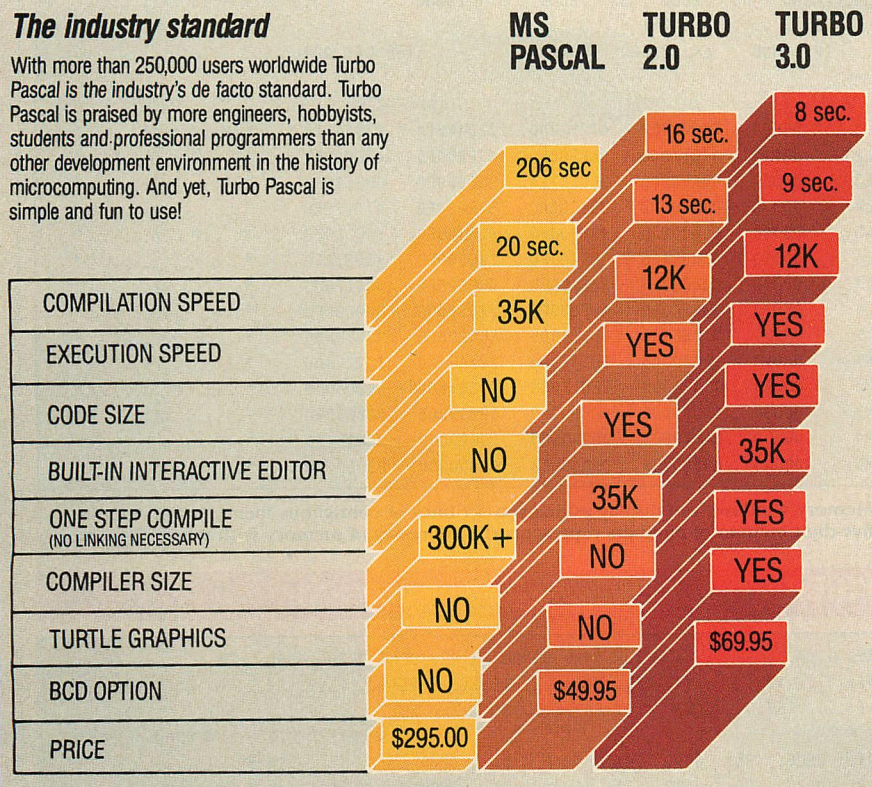
When RDT is first activated, the memory window will appear as shown in figure 1. The leftmost five-digit column of numbers in the memory window shown in figure 1 represents the addresses of memory. Note that these are five-digit addresses. While the DS plus offset may be used to set the addresses, RDT works primarily with five-digit addresses rather than segment register plus displacement addresses. What figure 1 shows is the actual content of memory at segment 0, offset 0. That does not seem particularly useful until the command L1=DS is entered. Then the screen displays the memory beginning with the segment addressed by the DS segment register.

Complex expressions are supported: DS+DX or DS+BX+SI+17, for example, are valid operands. Or, expressions such as L1=DS+SI and M1=ES+DI can be entered to split the body into two windows, one starting on the L1 line and the other on the M1 line—each, of course, displaying its own effective memory address. As many as 14 one-line windows can be dis-

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(*) Benchmark run on an IBM PC using MS Pascal version 3.2 and the DOS linker version 2.6. The 179 line program used is the "Gauss-Seidel" program out of Alan R. Miller's book: *Pascal programs for scientists and engineers* (Sybex, page 128) with a 3 dimensional non-singular matrix and a relaxation coefficient of 1.0.

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played simultaneously. Getting rid of multiple windows requires only one command or a few cursor movements.

The cursor, which is normally on the command line, is shown in the figure near the left border, about one-third of the way down the screen. It is marked by a broad arrow. To move the cursor away from the command line, the numeric key pad arrow keys are used. Scrolling is supported when the cursor is positioned to the body of the display, and changing data is done by moving the cursor to the desired position and entering the data. One useful gimmick is the ability to move the cursor to the ASCII (or EBCDIC) portion of the body, and entering ASCII characters. When the cursor is positioned in the hex portion of the display, data must be entered in hex notation.

Finally, pressing F3 will cause the ASCII portion of the body to display all characters (including nonprintable ones), while pressing it again will restore the display shown in the figure with only printable characters displayed (dots, for nonprintable characters).

Entering a DW command causes the disassembled window to show the instruction sequence at the next instruction to be executed, as shown in figure 2. Assume that an assembly language user wants to debug one module and knows the segment and offset of that module from a link map. On the right side of the line immediately above the command line of the disassembly window is the field CO:..... This is the current code origin. By entering the command CO=01234, the display will change to include this value in the CO: field. At the time this command is accepted, the LC (location counter) field will also change, as will the body of the display. If the first addressable line of code is found in the module at 1234H, the offsets now shown will match those shown in the user's assembly listing. Notice that the addresses of the call and jump instructions have also been adjusted to use this same relative offset, so that even the short jumps are fairly easy to relate to the display.

The disassembly window display can be scrolled by moving the cursor away from the command line, and then using the cursor control keys. Scrolling backwards by screen is not possible. Scrolling forward and backward can be done one byte at a time. This procedure is tricky, since if the scrolling ends when it is not aligned with a true instruction boundary, the disassembly probably will not resemble the code. Breakpoints, interrupts, and page scrolling must always align with an instruction boundary. Character scrolling is useful for code that is interspersed with data constants. The disassembler is not smart enough to decode those kinds of combinations.

The cursor may be returned to the command line by pressing the Home key, which is obviously necessary before attempting to enter a command. Code may be changed by simply keying hexadecimal nibbles over the existing instructions, with an instantaneous disassembly of the results.

The command ST (step) causes the display to single step to the next instruction, thereby allowing the user to watch the execution of a program. To execute 10H instructions, enter ST 10.

FIGURE 1: *RDT Memory Window Display*

```
REL 1.00          IBM PERSONAL COMPUTER RESIDENT DEBUG TOOL   D1       07/01/84
V1:..... V2:..... V3:..... V4:..... V5:..... V6:..... V7:..... V8:..... V9:.....
S1:..... S2:..... S3:..... S4:..... S5:..... S6:..... S7:..... S8:..... S9:.....
                                              DISPLAY: ASCII     WINDOW: MEMORY
AX:  28CE   BX:  0000   CX:  00FF   DX:  28B8            TR:00  .....-.....
SP:  003C   BP:  0000   SI:  0001   DI:  0100     FL:F246 OF:0 DF:0 IF:1 TF:0
CS: 28C80   DS: 28CE0   SS: 28D00   ES: 28B80       SF:0 ZF:1 AF:0 PF:1 CF:0
    LC: ....        INT     3                                        OP: .....
    IP: 000D    EX: 28C8D   CC             STEP CT: 0001  CO: .....
==>

L1   * 00000   7230E300   47017000   7104A71A   C304A71A     *r0..G.p.q.......*
L2     00010   47017000   54FF00F0   47FF00F0   47FF00F0     *G.p.T...G...G...*
L3     00020   A5FE00F0   9607A71A   DDE600F0   DDE600F0     *................*
L4     00030   DDE600F0   DDE600F0   57EF00F0   47017000     *........W...G.p.*
L5     00040   65F000F0   4DF800F0   41F800F0   59EC00F0     *e...M...A...Y...*
L6     00050   5C007A10   59F800F0   2EE800F0   9C007A10     *..z.Y.........z.*
L7     00060   000000F6   F2E600F0   6EFE00F0   40017000     *........n.....p.*
L8     00070   53FF00F0   A4F000F0   22050000   000000F0     *S...............*
L9     00080   070BE300   80019D05   8C029D05   99029D05     *................*
M1     00090   E2049D05   E013E300   2E14E300   1327E300     *................*
M2     000A0   130BE300   2E017000   00000000   00000000     *......p.........*
M3     000B0   00000000   00000000   6D039D05   00000000     *........m.......*
M4     000C0   EA140BE3   00000000   00000000   00000000     *................*
M5     000D0   00000000   00000000   00000000   00000000     *................*
```

Memory windows can display as many as 14 lines of contiguous memory. The leftmost five-digit column of numbers represents the addresses of memory with which RDT works.

FIGURE 2: *RDT Disassembly Window Display*

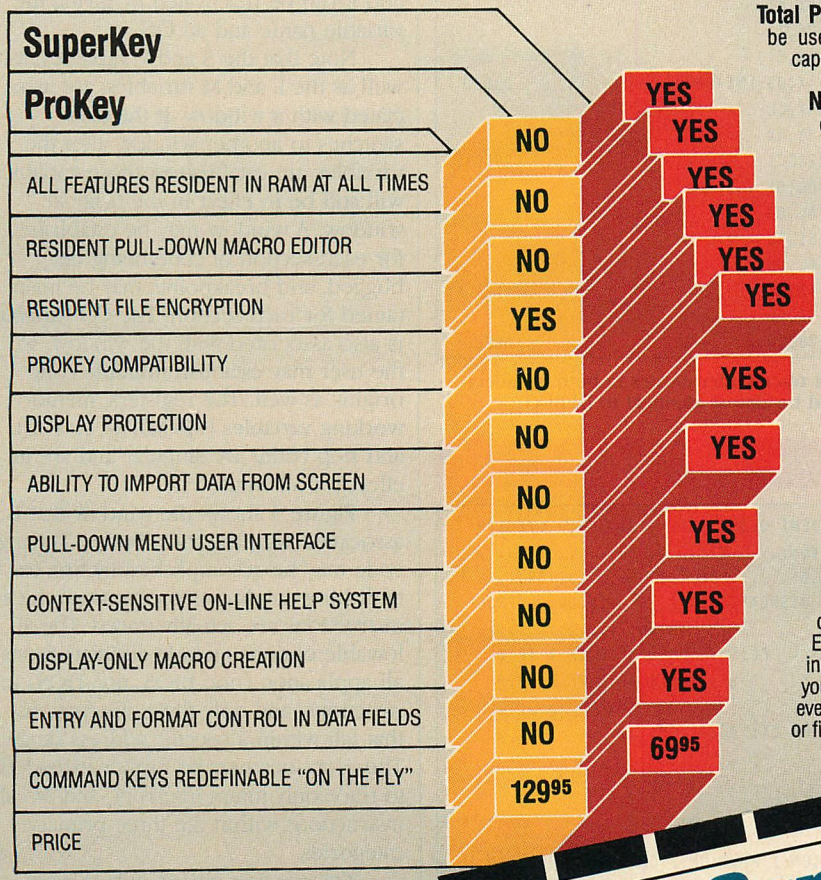
```
REL 1.00          IBM PERSONAL COMPUTER RESIDENT DEBUG TOOL   D1       07/01/84
V1:..... V2:..... V3:..... V4:..... V5:..... V6:..... V7:..... V8:..... V9:.....
S1:..... S2:..... S3:..... S4:..... S5:..... S6:..... S7:..... S8:..... S9:.....
                                              DISPLAY: ASCII     WINDOW: DISASM
AX:  28CE   BX:  0000   CX:  00FF   DX:  28B8            TR:00  .....-.....
SP:  003C   BP:  0000   SI:  0001   DI:  0100     FL:F246 OF:0 DF:0 IF:1 TF:0
CS: 28C80   DS: 28CE0   SS: 28D00   ES: 28B80       SF:0 ZF:1 AF:0 PF:1 CF:0
    LC: ....        INT     3                                        OP: .....
    IP: 000D    EX: 28C8D   CC             STEP CT: 0001  CO: .....
==>

L1: *  28C80:000D  CC            INT     3
L2:    28C80:000E  83FE06        CMP     SI,06
L3:    28C80:0011  742D          JZ      28CC0                       28CC0
L4:    28C80:0013  BB0E00        MOV     BX,000E
L5:    28C80:0016  A11700        MOV     AX,DS:[0017]                28CF7=0000
L6:    28C80:0019  FF061700      INC     WORD PTR DS:[0017]          28CF7=0000
L7:    28C80:001D  D7            XLAT
L8:    28C80:001E  3C30          CMP     AL,30
L9:    28C80:0020  7415          JZ      28CB7                       28CB7
M1:    28C80:0022  2C31          SUB     AL,31
M2:    28C80:0024  8BF8          MOV     DI,AX
M3:    28C80:0026  D1E7          SHL     DI,1
M4:    28C80:0028  8BCE          MOV     CX,SI
M5:    28C80:002A  8B850000      MOV     AX,DS:[DI+0000]             28DE0=0000
```

Disassembled instructions can be scrolled and changed by the user. Scrolling can be tricky because it must end when aligned with an instruction boundary.

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FIGURE 3: *Partial Trace Window Display*

```
REL 1.00          IBM PERSONAL COMPUTER RESIDENT DEBUG TOOL   D1       07/01/84
V1:..... V2:..... V3:..... V4:..... V5:..... V6:..... V7:..... V8:..... V9:.....
S1:..... S2:..... S3:..... S4:..... S5:..... S6:..... S7:..... S8:..... S9:.....
                                          DISPLAY: ASCII     WINDOW: TRACEP
AX:  28CE   BX:  0000   CX:  00FF   DX:  28B8            TR:02  00000-00000
SP:  003C   BP:  0000   SI:  0001   DI:  0100     FL:F293 OF:0 DF:0 IF:1 TF:0
CS: 28C80   DS: 28CE0   SS: 28D00   ES: 28B80        SF:1 ZF:0 AF:1 PF:0 CF:1
    LC: ....        MOV     BX,000E                                  OP: .....
    IP: 0013    EX: 28C93   BB0E00          STEP CT: 0001  CO: .....
==> EX

TB: 000D  28C80:0024  8BF8          MOV     DI,AX
TB: 000C  28C80:0026  D1E7          SHL     DI,1
TB: 000B  28C80:0028  8BCE          MOV     CX,SI
TB: 000A  28C80:002A  8B850000      MOV     AX,DS:[DI+0000]                 28DE0
TB: 0009  28C80:002E  D3E8          SHR     AX,CL
TB: 0008  28C80:0030  8BD8          MOV     BX,AX
TB: 0007  28C80:0032  E80C00        CALL    28CC1                           28CC1
TB: 0006  28C80:0041  E461          IN      AL,61
TB: 0005  28C80:0043  0C03          OR      AL,03
TB: 0004  28C80:0045  E661          OUT     61,AL
TB: 0003  28C80:0047  B0B6          MOV     AL,B6
TB: 0002  28C80:0049  E643          OUT     43,AL
TB: 0001  28C80:000E  83FE06        CMP     SI,06
TB: 0000  28C80:0011  742D          JZ      28CC0                           28CC0
```

This window is a partial trace form containing 14 trace buffer entries in both hexadecimal and disassembled format. The full form would be almost identical to DEBUG.

FIGURE 4: *Numeric Math Coprocessor Window Display*

```
REL 1.00          IBM PERSONAL COMPUTER RESIDENT DEBUG TOOL   D1       07/01/84
V1:..... V2:..... V3:..... V4:..... V5:..... V6:..... V7:..... V8:..... V9:.....
S1:..... S2:..... S3:..... S4:..... S5:..... S6:..... S7:..... S8:..... S9:.....
                                        DISPLAY: ASCII     WINDOW: COPROC
AX:  148E   BX:  0000   CX:  00FF   DX:  1478            TR:00  .....-.....
SP:  003C   BP:  0000   SI:  0001   DI:  0100     FL:F246 OF:0 DF:0 IF:1 TF:0
CS: 14880   DS: 148E0   SS: 14900   ES: 14780        SF:0 ZF:1 AF:0 PF:1 CF:0
    LC: ....        INT     3                                        OP: .....
    IP: 000D    EX: 1488D   CC              STEP CT: 0001  CO: .....
==>

                          MATH COPROCESSOR STATE

CONTROL WORD : 03FF      IC:0 RC:00   PC:11  IEM:1 PM:1 UM:1 OM:1 ZM:1 DM:1 IM:1
STATUS WORD  : 4100      B:0  CC:1001 ST:000  IR:0 PE:0 UE:0 OE:0 ZE:0 DE:0 IE:0

                                    SIGN  EXPONENT      SIGNIFICAND       TAG
                              ST      1      7ADE    10E4 75E0 AE9D 0E9D    11
    EXCEPTION POINTERS        ST(1)   1      7A88    9C67 55A4 CF71 4AD1    11
                              ST(2)   1      7A90    9CE9 70AA C269 1EDD    11
INSTRUCTION ADDRESS : FFFFF   ST(3)   1      7A80    8DCE 12A8 82A8 DE8D    11
INSTRUCTION OPCODE :  D800    ST(4)   1      7A88   0882 10A3 E42D 9A5D    11
OPERAND ADDRESS :     FFFFF   ST(5)   1      7AC6    1D48 15E6 B595 5E51    11
                              ST(6)   1      7A88    8500 12A5 F354 0A09    11
                              ST(7)   1      7AD6    1107 30EB DC78 8E05    11
```

Provided a math coprocessor is installed, this window displays the state of the register stack, status words, and exception pointers. Memory alteration is not permitted.

In this latter instance, the display will show the end result, but does not single step through the instructions.

Two features make single stepping much easier. First, any command that is prefixed by a "/" remains on the command line after execution. Entering /ST allows the user to single step through a program by pressing the Enter key repetitively. Second, by entering the command Fn, where *n* is 7, 8, or 9, and then entering a command or command string, the user has assigned that string to the corresponding function key. Pressing the function key after that assignment repeats the command.

The third line of the heading displays the current content of up to nine breakpoints (S1 through S9). If the instruction at which the user wishes to break is displayed, then setting the breakpoint is as easy as S1=M3. This will set a breakpoint (S1) at the instruction displayed on line M3. The second line (V1 through V9) can be used either for breakpoints or as working variables. Breakpoints can be cleared by entering the variable name with a null entry, or by entering the variable name followed by the word OFF. This method leaves the address of the breakpoint in place, and it can be reactivated by giving the variable name and an ON.

Note that the S and V variables, as well as the L and M variables, are associated with a window. If the user switches to another window after the variables are established, those variables will still be in effect in the original window. A window may be established for each section of code being debugged, and breakpoints may be maintained for each section. The CO variable is also associated with the window, so the user may establish multiple code origins as well. The registers, memory, working variables (M6-M9, W, X, Y, Z), and step count are singular and are in effect for all windows.

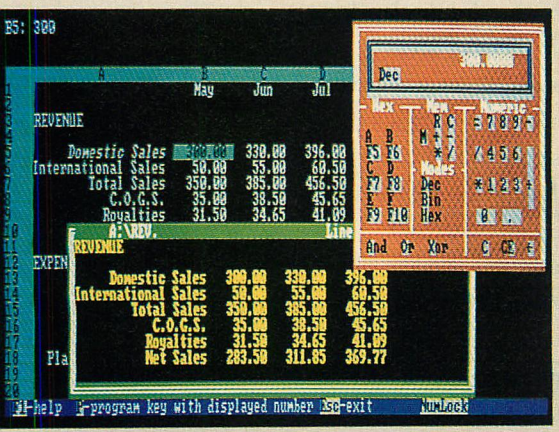
Figure 3 shows the window that is associated with the trace buffer. Tracing code may be accomplished by first establishing conditions concerning which instructions are actually traced. The allowable options include all instructions, all application (non-BIOS, non-DOS) instructions, and only those instructions that fall within a specific address range. These options may be further extended to trace only jump, interrupt, and/or call instructions within the three primary categories.

Trace action occurs only during stepping and continues until a break—a hard interrupt, a breakpoint, or a soft interrupt—occurs or the step count is exhausted. Two other options are available at the trace command level. The user may force a break on occurrence of the first traced instruction or when the trace buffer is full.

The trace buffer size is established at load time and may vary from 32 to 2,340 instructions. It is a circular buffer, so the importance of the buffer full break is obvious. Displaying the trace window causes the most recently executed instruction to appear at the bottom of the window. This arrangement presents the displayed instructions in the sequence they were executed.

The window may be displayed in two forms. The form shown in figure 3 is the partial trace form and includes a disassembled instruction sequence. The

Borland's SideKick™ 1984 Product of the Year*

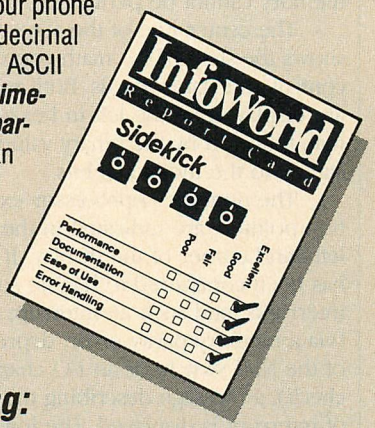


Here's SideKick in action with Lotus® 1-2-3 running underneath. Data has been imported from Lotus to SideKick's **notepad**, shown in the lower portion of the screen. The notepad is a full-screen editor that lets you import and export data; it utilizes WordStar commands to let you time- and date-stamp notes and save them to disk. The SideKick **calculator**, shown at the upper right, offers memory capability, nested parentheses, and the ability to convert decimal to hexadecimal or binary. It even lets you transfer resulting figures to your underlying application.

The Critics' Choice *What more can we say?*

"SideKick™ stands in the shadows behind whatever program you are using, ready to jump forward when you need it. The program's various functions use windows that overlay the display you are working with and restore the screen when you are through. The program contains a respectable word processor for note taking, a dialer that your smart modem can use with your phone list, a calculator for hexadecimal/binary/decimal arithmetic, an appointment calendar and an ASCII table for programmers . . . ***SideKick is a time-saving, work-saving, frustration-saving bargain.*** Having a programmer's calculator, an appointment calendar, and a notepad at your beck and call, no matter what program is running, is the first big step to making the paper and pencil obsolete."

—Dan Robinson of InfoWorld

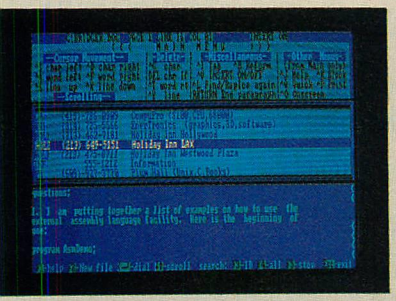


And he's not the only one talking:

Charles Petzold, PC Magazine: *"In a simple, beautiful implementation of WordStar™'s block copy commands, SideKick can transport all or any part of the display screen (even an area overlaid by the notepad display) to the notepad."*

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Garry Ray, PC Week: *"SideKick deserves a place in every PC."*



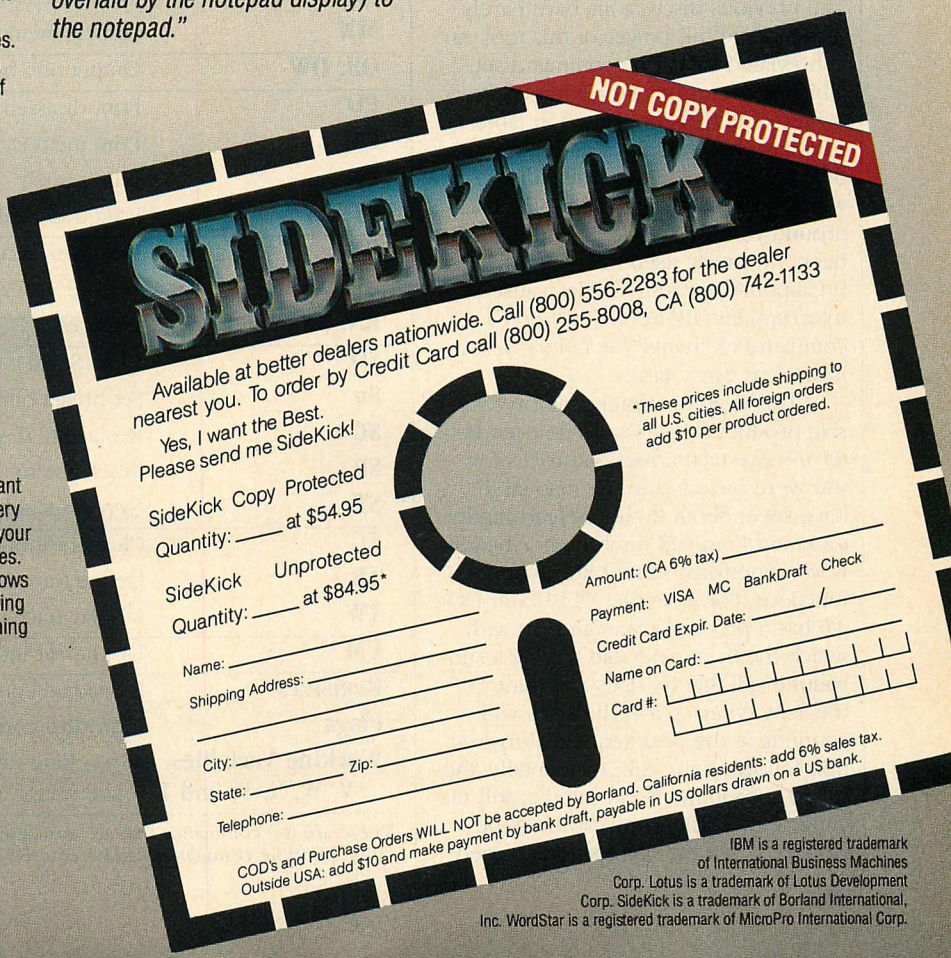
The **telephone autodialer/directory** places calls for you via your Hayes™-compatible modem and locates numbers from one of the program's several directories. Here the dialer is running on top of WordStar.

The **calendar** can record appointments, records and notes—yours or those of the entire department—up to the year 2099. Here the dialer is running on top of Lotus.





The **ASCII reference table**, important enough to be in every manual, is now at your fingertips at all times. Here the screen shows all windows, including an ASCII table running over Lotus.



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full trace form is almost identical to that produced by DEBUG, showing the register contents as well as the instruction for each element of the trace. In this form, the body of the trace window will show only three instructions.

The upper half of the numeric coprocessor screen, shown in figure 4, is similar to the other window modes. The lower half of the display shows the current state of the math coprocessor. This window can be accessed only if the coprocessor is actually installed. This mode is read-only; alterations to memory cannot be performed.

The center line of the screen shows the state of the math coprocessor control and status words. Both words are displayed on the left in hexadecimal, followed by the binary values assigned to the individual bits.

The numeric coprocessor exception pointers are indicated in the lower left-hand corner of the display. If RDT has been configured to handle soft NMI interrupts, and such an interrupt occurs (via a memory parity error, depression of the NMI switch, or an I/O channel check), a message describing the type of interrupt is displayed. The lower right quadrant of the display shows the contents of the numeric coprocessor register stack, including the sign, exponent, significand, and tag value.

COMPLAINTS

The previous discussions have barely exposed the full power of this tool. An abbreviated list of the command set, which gives further indication of the power of RDT, is presented in table 1. IBM has observed all of its regular niceties. For example, on a color display the windows appear on an IBM blue background with white letters, and color has been effectively used to show active breakpoints, current activity, cause of interrupt, etc. IBM even included a command to change the colors to suit individual users' tastes.

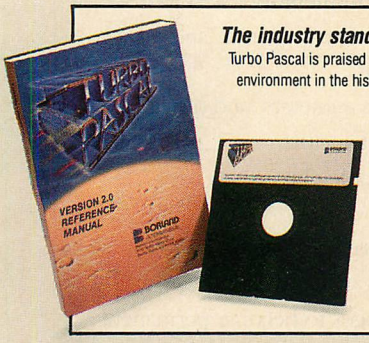
This is an extremely comprehensive product, but it would be even better if more techniques and tricks for use were included in the manual. I have spent about 20 hours learning this tool, and I am still fumbling for better ways to perform some rather common functions. For example, DEBUG in DOS 3.0 has a proceed command (P) with which the user can avoid tracing a subroutine call that he does not want to trace; by entering a P, the trace will continue at the next sequential instruction following the call. Incidentally, the called subroutine is executed at full machine speed. The same can be done with RDT, but the command is buried

TABLE 1: *RDT Command Summary*

RDT COMMAND	FUNCTION
AS	Set memory window character display to ASCII
CA	Set RDT color attributes
CD	RDT displays on color display device
CM	Compare two memory areas
CO	Set Code Origin, aligning relative offsets
CP	Copy one memory area to another
CT	Set default step count
CW	Display math coprocessor window
Dn	Display saved window (n=1 . . . 9)
DW	Display disassembly window
EB	Set memory window character display to EBCDIC
EX	Execute the test program
Fn	Assign command string to F7, F8, or F9 keys
FA	Find ASCII string in memory
FE	Find EBCDIC string in memory
FX	Find hexadecimal string in memory
HP	List all RDT commands (two characters)
IB, IW	Read byte/word from input port
LO	Clear L1-L9 variables
Ln	Set memory address variables
LC	Set the pseudolocation counter
MO	Clear M1-M9 variables
Mn	Set memory address variables
MD	RDT displays on the monochrome device
MS	Memory space available
MW	Display memory window
OB, OW	Output one byte/word to port
PD	Print disassembled instruction block
PM	Print memory block—hex and character
PR	Print screen
PT	Print trace buffer
RD	Read disk sector
RK, SK	Restore/set INT 5 vector
RN, SN	Restore/set INT 2 vector
SO	Clear S1-S9 breakpoint variables
Sn	Set breakpoint variable (n=1 . . . 9)
SC	Replace RDT screen with test program screen
SR	Reset system (reboot DOS)
ST	Step (execute) test program "N" instructions
TC	Clear trace buffer
TR	Define trace activity
TW	Display trace window
UM	Display/set interrupt mask
Registers	Individual commands to set all 8088 registers
Flags	Individual commands to set all 8088 flags
Working Variables, V, W, X, Y, and Z	45 working variables that may be set/cleared by individual and vector commands.

These are the commands that are available for use with the IBM Professional Debug Facility. Multiple commands can be entered by separating each one with a semi-colon.

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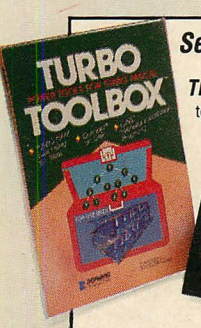


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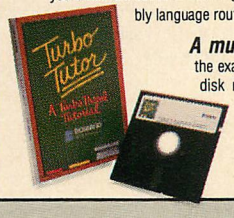
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in the description of one (and only one) of the commands, where the user has to find it by accident. The command is S1=EX+IL;EX. Decoded, that means set a breakpoint at the current instruction plus its length, and then enter into execution. By setting this up as one of the function keys, the user can execute a command with the single key press provided in DEBUG.

The manual contains no reference to any function keys other than F3 and F7 through F9. All of them, however, are active and apparently do some useful work. Even a few words of explanation would have been helpful.

Another complaint about RDT involves making code modifications on the window. Changes must be made in hex, rather than using the A (for assemble) command of DEBUG.

The RDT trace seems to be considerably slower than when using DEBUG. With the full screen window to update, the trace buffer to maintain, etc., this sluggishness is to be expected.

DISK REPAIR

The second package in the Professional Debug Facility is the Disk Repair program, which as its name implies, works with the data recorded on disk. *Repair*, however, may have the wrong connotation. This utility:

- Displays or changes sectors (physical or logical), files, or clusters
- Changes file attributes
- Looks at drive parameters
- Modifies the File Allocation Table
- Generates calls or interrupts to BIOS, DOS, or other resident programs

Disk Repair has the nice feature of being able to work with either DOS or physical sectors; it will also work with files. The mapping for these three uses is quite different. Table 2 is a quick reference list of the commands, while figure 5 is the main menu. Each of the functions listed in figure 5 is backed up by a full screen display.

This utility requires tender loving care. It lets the user display and/or change any sector of a disk—even the File Allocation Table. The quickest known method for destroying data on a fixed disk is to wipe out the FAT, and this utility will happily do it, if used improperly. The manual describes a method to reclaim erased files under the normal, undisturbed diskette conditions. The product has the additional feature of being able to invoke an interrupt routine or a resident callable function from this process.

Disk Repair should not be used on a master diskette until the user has spent quite a bit of time with the product. Above all, it should not be used on a fixed disk, until the user is totally comfortable with it. IBM seems to have selected the word *professional*, to designate very powerful products that do not have the elaborate set of protective and fail-safe features found in the conventional utilities. The Disk Repair program fits this pattern very well. Used carefully, it is extremely powerful. While it may not be worth the price of the total Professional Debug Facility, Disk Repair sure does offset the cost of RDT.

TABLE 2: *Disk Repair Commands*

DISK REPAIR COMMAND	FUNCTION
A	Display characters in ASCII
C	Call a subroutine anywhere in memory
D	Use decimal radix for file size, parameters, and offsets
E	Display characters in EBCDIC
H	Use hex radix for file size, parameters, and offsets
I	Execute any of 256 interrupt vectors
P	Suppress display of unprintable characters (uses ".")
Q	Quit
S	Save current cluster to end of SAVE.DR file
U	Display all characters
W	Causes temporary disk changes to become permanent

This set of commands for the Disk Repair utility is useful for those procedures that cannot be performed directly with the cursor keys or by changing modes.

FIGURE 5: *IBM Disk Repair Utility Main Menu*

```
                          Disk Repair -- Main Menu


        F1: Help            - This menu of display modes
        F2: Explain         - Explanations of messages and fields
        F3: BIOS Sector     - Absolute (BIOS) sector mode
        F4: DOS Sector      - DOS sector mode
        F5: File            - DOS file mode
        F6: Memory          - Main memory mode
        F7: Directory       - DOS directory mode
        F8: F A T           - File Allocation Table mode
        F9: Parameter       - Disk parameters mode
        F10:Interrupt/Call  - Software interrupt and call mode

General instructions:

        Press the function keys to find the type of information you are looking
        for.  To change anything, such as the sector number, the drive
        number or the data, move the cursor to the value you want to change and
        type over it. It's that easy.  If any field on the screen or any error
        message confuses you, press F2 to get an explanation.

        Use the Quit command to return to DOS.
Command:
  (Press F2 for an explanation of things.)

                          Dis
```

The main menu of the Disk Repair utility provides access to each of the various disk repair modes, as well as to on-line explanations of the fields and messages.

Professional Debug Facility: $150
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Dan Daetwyler spent 22 years with IBM before retiring in 1981 from his position there as manager and systems architect. He has been studying and working with microcomputers for the past 10 years.

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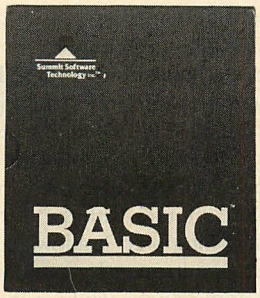
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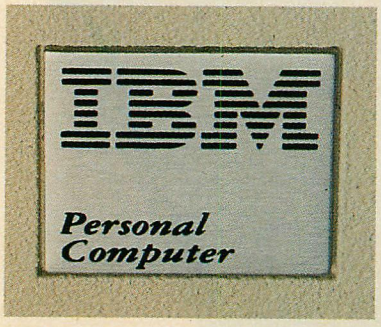
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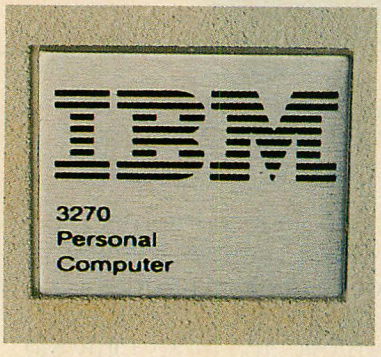
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Programming for the 3270-PC

PC programming techniques can be applied to 3270-PC applications—with some, usually minor, modifications.





ARMEN HARIAN and JEFFREY KRANTZ

The responsibility for controlling the enhanced function and capability of the IBM 3270-PC lies at least in part with the 3270-PC Control Program. It is this program and some unique hardware that make the 3270-PC somewhat different from the PC or PC/XT. These differences also result in certain incompatibilities between the two machines that must be considered by the programmer in developing applications for the 3270-PC.

The 3270-PC is an intelligent workstation that combines the power of the mainframe computer with the flexibility of the microcomputer. It allows a user to interact simultaneously with up to four host applications, while at the same time having access to a PC application. In addition, the user also may have two notepad areas available for use. These seven activities (called sessions) may be viewed concurrently by the user with the windowing capability provided by the 3270-PC Control Program. All of these applications may be active at the same time, allowing the user to interact with one of the sessions while the remaining applications (PC or host) continue to execute.

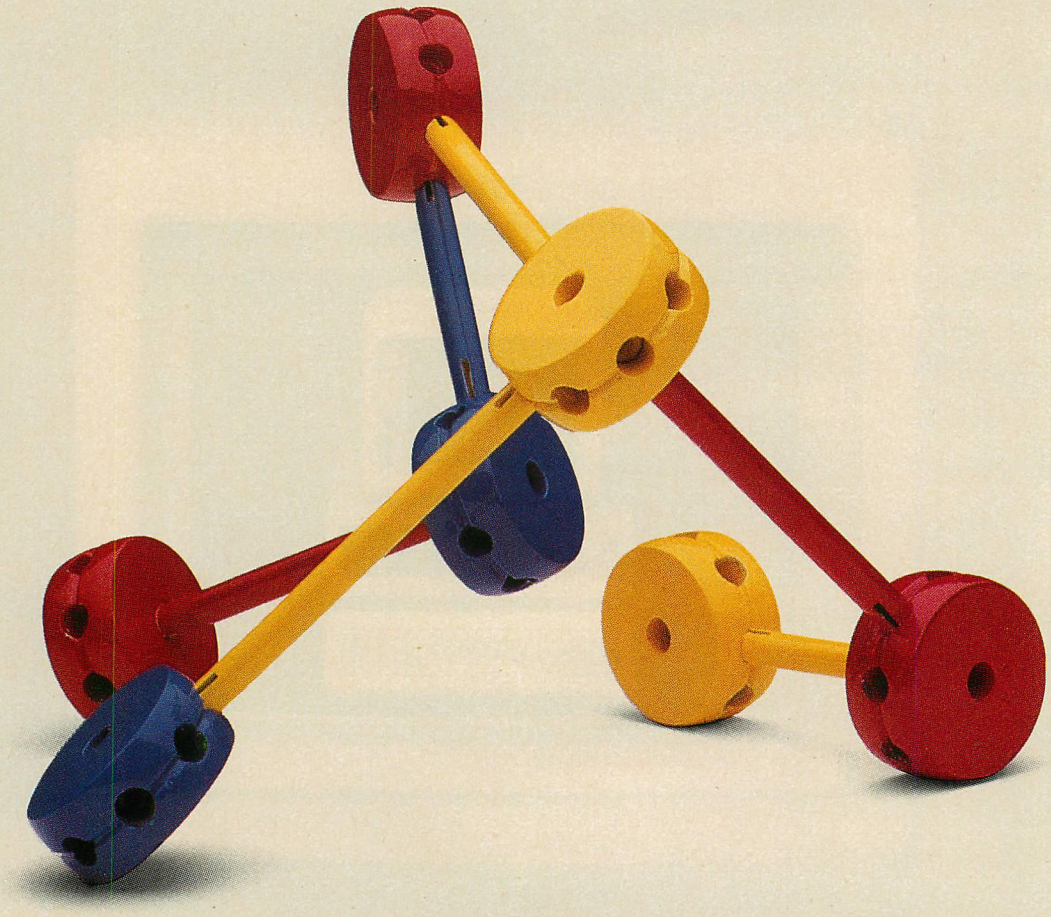
The control program for the 3270-PC, which may be viewed as an extension of DOS, is resident in main memory when the hardware is executing as a 3270-PC (the hardware may also act as a PC when IPLed with DOS but without the 3270-PC Control Program). The following assumes release 1.2 of the 3270-PC is resident in memory.

One major similarity between the 3270-PC and the PC is that they use the same PC-DOS operating system and BIOS. This allows applications with these interfaces to continue to use most of the services in a transparent manner when executing on the 3270-PC. Basically, PC applications that follow DOS (2.0 and later versions) and BIOS protocols and conventions should execute with no problem on the 3270-PC.

While many PC applications will run unchanged on the 3270-PC, some require adaptation in order to execute. Two areas of compatibility must be addressed when determining whether a PC application is compatible with the



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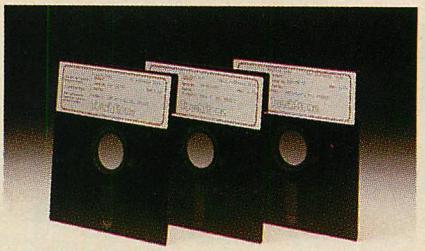
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3270-PC: data acquisition compatibility and processing compatibility.

Data acquisition refers to the way in which an applications program acquires the data it uses during the course of its execution. The degree of compatibility of data acquisition methods on various types of hardware and operating systems determines to a large extent whether an application will execute in a specific environment.

Most PC applications acquire data by using one of three standard devices: the keyboard, the disk/diskette secondary storage medium, and the asynchronous communications adapter. The converged 3270-PC keyboard includes all of the keys from the standard PC keyboard. Although some of these keys are physically in different positions on the 3270-PC keyboard, an end user should have no difficulty entering any of the data from the converged keyboard that could have been entered from the standard PC keyboard. In addition, the scan codes that are sent from the 3270-PC keyboard are identical to those sent from the PC keyboard.

The PC keyboard transmits a scan code for each key when it is depressed (the *make* code) and another when the key is released (the *break* code). All the PC keys are typematic and operate in make/break mode (a make scan code is sent on key depression and break scan code is sent on key release).

- Typematic: Make scan codes are transmitted as long as the key is depressed. The remaining keys normally available to a PC application fall into this category.

In order to simulate the PC keyboard as closely as possible when the keyboard is attached to the PC session, a *pseudobreak* code is transmitted by the 3270-PC Control Program for the make only and typematic keys. This pseudobreak scan code is the same value as the normal break code; however, it is sent immediately following the make scan code, and not at the time the key is released.

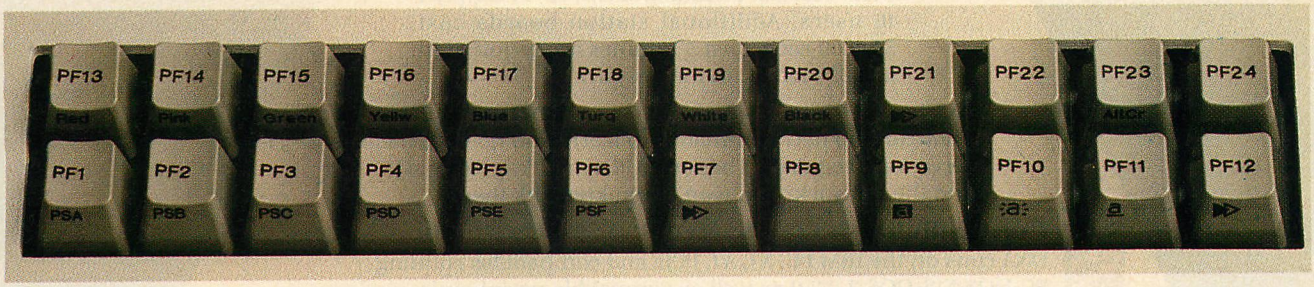
Because of the way in which keystrokes destined for the PC application are handled, the PC application may address the keyboard hardware directly. Complete transparency is maintained for the scan codes that are transmitted. A word of caution is necessary, however, for applications that go directly to the keyboard for input data. Normally, BIOS updates the shift state flags for each keystroke. But when applications intercept the BIOS keystroke interrupts and the interrupt is not passed on to BIOS (as is the normal accepted practice when intercepting interrupts), it becomes the responsibility of the application to update the shift state flags when triggered by the shift keys. Failure to do so may yield unpredictable results in other areas of 3270-PC operation.

available on the PC is also available for the 3270-PC. However, changes may be required to the method with which the application receives control when it is executing concurrently with the 3270-PC Control Program.

Applications that are written specifically for the 3270-PC have a number of additional sources of data that are not available on the standard PC. These sources, which include the display screen and host applications via the 3270-PC communications facilities, are available through the 3270-PC Application Programming Interface (API). Users should refer to IBM Document SC23-0165, *IBM 3270 Personal Computer Programming Guide*, and the IBM 3270-PC High-Level Language Application Program Interface (program number 1753180 feature 9357) for additional information on the 3270-PC API.

PROCESSING COMPATIBILITY

Processing compatibility refers to the ability of a PC application to execute—and obtain the same results—in a 3270-PC operating environment in the same way that it does in a PC environment. Most DOS and BIOS interfaces yield the same result on the PC and the 3270-PC. Most of the differences in processing can be traced to the 3270-PC Control Program and the unique hardware that replaces standard PC hardware, such as the 3270-PC display adapter.



The keys of the 3270-PC keyboard fall into one of three mutually exclusive categories:

- Make only: Only the make scan code is sent on key depression. The break scan code is not transmitted when the key is released. The keys available to a PC application in this category are the program function keys; the Print key; the Enter key; the 3270 Insert and Delete keys; and the numeric keypad Esc, NumLock, ScrollLock, Space, Plus, and Delete.
- Make/break: The make scan code is transmitted on key depression; the break scan code is transmitted on key release. The keys available to a PC application that fall into this category are: Ctrl, both Alt keys, both Shift keys, and CapsLock.

A second standard device through which most PC applications acquire data is disk storage. Standard DOS files residing on hard disk or diskette are available to a PC application executing on a 3270-PC in exactly the same way as on a standard PC. The 3270-PC Control Program will not interfere with the application's normal DOS interface to these secondary storage media.

DOS files created on both the PC and the 3270-PC are identical. Data interchange between the two machines is transparent (that is, DOS files created on one can be read on the other).

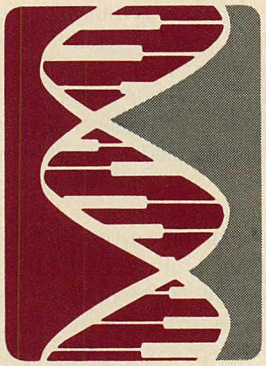
Applications that acquire data from the third standard device—an asynchronous communications adapter—can interface to the adapter in the same way as on the PC since the adapter that is

The single, most important guideline for a programmer to observe when writing an application for the 3270-PC is to have the application use only the approved DOS and BIOS published interfaces to access hardware, or other software, whenever possible. Any use of nonstandard interfaces or direct access to the hardware should be done with caution and in full knowledge of potential immediate or future incompatibility with the 3270-PC.

A programmer, however, may have valid reasons why an application should not always adhere to the DOS and BIOS protocols and conventions—for example, the desire to increase performance. The following guidelines cover some of the information needed by the 3270-PC applications developer who must legiti-

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mately bypass the DOS and BIOS protocols and conventions.

An application may perform the following test in order to determine if it is executing on a 3270-PC:

- Perform a function call (INT X'10') to the BIOS Video Routine with these parameters: AH Register = X'30'; AL Register = X'00'; CX Register = X'00'; DX Register = X'00'.
- If the CX and DX registers are still 0 on return, the machine is not a 3270-PC. If the CX and/or DX registers are not 0, the machine is a 3270-PC.

In some cases, programming errors that go undetected on the PC may cause undesirable results on the 3270-PC. The applications developer should keep in mind that applications should not address hardware without full knowledge of what is actually supported. Some PC and PC/XT hardware is simulated, wholly or only in part, and may not be supported. The Motorola 6845 Display Controller, which is simulated, exemplifies this situation. Only those PC registers that are actually supported for the 6845 should be addressed.

Not all non-IBM hardware that works on the PC will continue to work with the 3270-PC. Special consideration must be given to testing such hardware in the 3270-PC environment.

Applications executing on a PC may address unknown I/O ports (I/O addresses) with impunity since this action is not considered an error in the PC environment. The 3270-PC Control Program uses some I/O addresses not used in the PC environment. Indiscriminate access to these ports could have undesirable side effects.

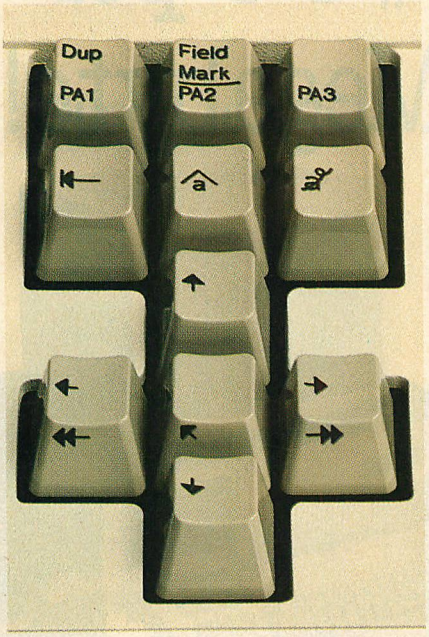
Memory usage is an important consideration to the 3270-PC programmer. The 3270-PC Control Program resides in memory above DOS, at the highest end of memory. When the control program is loaded, the BIOS high address is modified to reflect the reduction of memory caused by the residence of the 3270-PC Control Program. If the PC application uses memory without paying attention to the BIOS high memory limit, it could overwrite a portion of the 3270-PC Control Program.

Applications, therefore, must always use the BIOS high memory address as the usable limit of memory and must not use the hardware memory DIP switches or scan memory to determine the extent of installed memory. This would yield misleading information.

Additionally, applications executing in the 3270-PC should observe the DOS and BIOS memory conventions. Specifically, they must not attempt to take over the memory management. Instead, the application should remain in its normal DOS region of memory and use DOS for additional memory allocation.

A word of caution for the programmer who uses a CONFIG.SYS file to install device drivers: there is a small amount of time in the early part of the 3270-PC IPL sequence when the BIOS high address limit has not yet been properly adjusted to installation of the 3270-PC Control Program. It is normally during this period that DOS will attempt to read the CONFIG.SYS file if there is one. Since the BIOS high memory limit has not yet been adjusted for the 3270-PC Control Program, the device drivers may be placed in an inappropriate portion of high memory. The subsequent loading of the control program may overlay these device drivers.

If the device drivers have modified device addresses in BIOS, these addresses will now point to locations in



memory overwritten by the control program. In most cases, this condition will be automatically corrected during the remainder of the IPL sequence. In some cases, however, device drivers may attempt to take over devices used during the IPL sequence, and this is where a problem could likely occur.

The IPL sequence of the 3270-PC goes through two boot phases: one in which the 3270-PC Control Program has not been installed and a second in which it has. It is during the second boot phase that device drivers are reinstalled correctly. If the second phase cannot proceed, however, the normal IPL sequence will not finish, and the system will be unusable. This will occur when IPL devices are taken over by device drivers during the first boot phase and, because they were overlaid during installation of the 3270-PC Control Program, the device drivers are no longer operative and cannot perform the second boot phase of the IPL sequence.

One solution is to execute the CONFIG.SYS file only during the second boot phase. This will prevent the BIOS device addresses for IPL devices from being altered and the device driver code from being installed until after the 3270-PC Control Program has been loaded. It can be accomplished by having the CONFIG.SYS file identified by another name during the first boot phase of IPL, which is done by correctly structuring the AUTOEXEC.BAT file used during the IPL sequence. An example of the statements needed at the beginning of the AUTOEXEC.BAT file is:

RENAME CONFIG.XXX CONFIG.SYS
(expose the CONFIG.SYS file)
INDCIPL (second boot phase)
RENAME CONFIG.SYS CONFIG.XXX (hide CONFIG.SYS for next IPL)

The source of many of the incompatibilities between the PC and the 3270-PC is the difference between their display adapters. The 3270-PC has more displays available to it than the PC. In addition to the normal PC monochrome display (IBM 5151), a high-resolution color display (IBM 5272) and a plasma display (IBM 3295) can be used with the 3270-PC. The information in this article is based on release 1.2 of the 3270-PC Control Program and pertains only to the 5272 color display and the 5151 monochrome display. The 5272 color display has eight available colors with a resolution of 720-by-350 pixels. In 80-character mode, this provides a 9-by-14 character cell.

In the 3270-PC, both the monochrome and the color displays are supported by a special display adapter that is different from the PC monochrome and color adapters. The incompatibilities created by the different adapters can be managed if the application adheres to certain guidelines.

The 3270-PC supports more than one type of monitor, but, unlike the PC, it does not support the monitors concurrently. This is because the 3270-PC maps both monitors to the same memory location. While both the monochrome and color refresh buffers (X'B0000' and X'B8000') are mapped to the same physical refresh buffer, applications should always access the correct address space based upon the monitor that is currently attached to the PC. This minimizes the chance of future incompatibility in case buffer utilization changes.

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Applications may directly access the memory mapped screen refresh buffer. The attribute bytes found in the refresh buffer will correspond to the specific type of monitor attached (the attribute bytes for color and monochrome are interpreted differently).

The PC color display adapter has a screen buffer that may be hardware scrolled (via the 6845 start address register) and may contain up to four screens worth of data; the 3270-PC display buffer is large enough only for a single screen of information. Applications, therefore, may address only page 0 of the color display buffer address space because this is the only valid page, and 6845-invoked hardware scrolling is not supported.

Applications must initialize the display using the BIOS interfaces provided. Special functions have been provided in the BIOS INT X'10' function call to support the capabilities of the 5272 display.

The 40-by-25 character mode is not supported in text mode on the 3270-PC. A BIOS call for this mode of operation will cause the display to enter the 80-by-25 character mode.

The 6845 display controller is emulated on the 3270-PC, but not all of the 6845 registers are supported. The only registers that should be accessed are the cursor address registers and the cursor start and end registers.

The only cursor sizes that are supported for the display are no cursor, the bar cursor, and the block cursor. The preferred way to make the primary cursor disappear is to set the Cursor Start Register to a value greater than the Cursor End Register. The three alternate cursors (blinking line, blinking block, and block) cannot be made invisible. Split cursors or other exotic cursor forms are not supported.

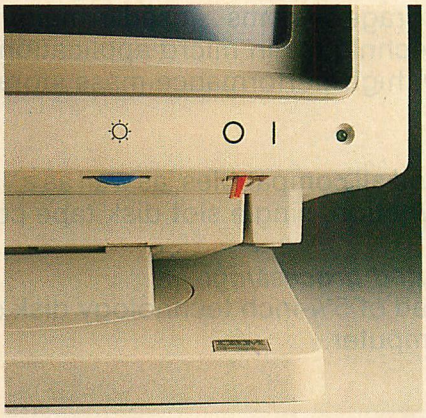
A 3270-PC window always follows and keeps the hardware cursor within its viewable area. This feature of the 3270-PC Control Program is referred to as *auto-windowing*. If a particular application does not use the hardware cursor, the section of the presentation space with which the user is interacting may disappear. This potential problem can be avoided by forcing the hardware cursor to follow the active portion of the window. Applications that use a logical cursor instead of the hardware cursor and that require the 3270-PC auto-windowing feature must keep the hardware cursor updated and in synchronization with the logical cursor (although the hardware cursor does not need to be displayed on the screen).

There is no DMA (Direct Memory Access) allowed to or from the display refresh buffer when in text mode. Basically, this means that the refresh buffer cannot be the source or the target of a file I/O request. Block moves continue to work with no problem.

Applications that assume graphics support because a color monitor is present must be changed to make an additional check for the 3270-PC graphics feature.

On the PC, the presence of a color display adapter implies APA graphics capability. This is not so for the 3270-PC because a separate graphics adapter is required for graphics support. Applications that assume graphics support because a color monitor is present must be changed to check for the 3270-PC graphics feature.

Device characteristics are different depending on the displays and display



adapters that may be used with the 3270-PC. An application may perform this test to determine the specific display attributes of the 3270-PC.

- Determine if the machine is a 3270-PC by performing the function call (INT X'10') to the BIOS video routine that was described earlier.
- On return from the INT X'10' BIOS call, the CX and DX registers contain the address of a segment and the offset, respectively, that point to a table defining the display hardware features being supported by this machine. A graphic representation of this table is depicted in figure 1.
- By reading the MONITOR ID byte (CX:DX+2), the application can determine which monitor type (display / display adapter) is currently installed. If the MONITOR ID byte is equal to X'00', additional testing can be done on I/O register X'188' to determine the type of monitor installed and the graphics mode supported. In order to determine to which mode (PC-compatible or full-screen) the adapter is initialized, the application may address bit 3 of I/O register X'197'.
- If the MONITOR ID byte (CX:DX+2) is not equal to X'00', then the monitor attributes must be determined by reading the FUNCTIONS 1 byte (CX:DX+6). These function identifiers indicate only that the capability exists in the display and not necessarily that the functions may be used simultaneously. For example, bits 0 and 1 indicate functions that are mutually exclusive (for example, the support of monochrome and color text). The FUNCTIONS 2 byte (CX:DX+7) may be used to determine other operating characteristics of the machine.

Some restrictions apply to the 3270-PC display adapter. For instance, a bar cursor is not visible on a white background on the 3270-PC color display. Therefore, it is advisable to use the block cursor whenever the cursor is positioned on a white background. Another restriction is that, unlike the standard PC, the 3270-PC does not support the intensity bit of the PC attribute byte. This means that only half of the 16 PC colors are available on the 3270-PC. Applications that use the intense version of colors for specific meaning instead should use some other form of demarcation, such as a different color.

The conversion chart that is shown in figure 2 may be used to determine the color that will be obtained on the 3270-PC when coding the character attribute byte.

Graphics support on the 3270-PC requires an additional hardware card to be attached to the display adapter card. Direct access to the screen refresh buffer is allowed in graphics mode.

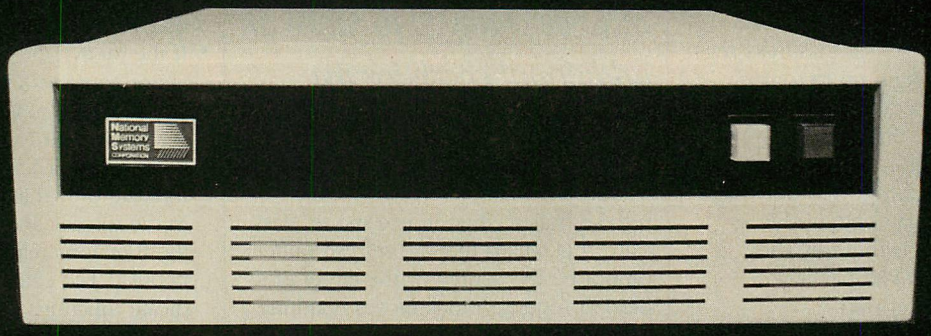
The graphics buffer starts at memory location X'B8000' as in the PC; it is different than the hardware buffer used for text, requiring that the display be initialized to graphics mode prior to writing graphics data to the refresh buffer. When starting or changing the mode of operation, the display must first be initialized for the specific mode of operation (character or graphics) before performing any I/O operation to the screen. The initialization should always be done through BIOS.

The 5272 monitor has two graphics modes: the PC-compatible mode, which works the same way as it does on a PC, including the separation of the odd and

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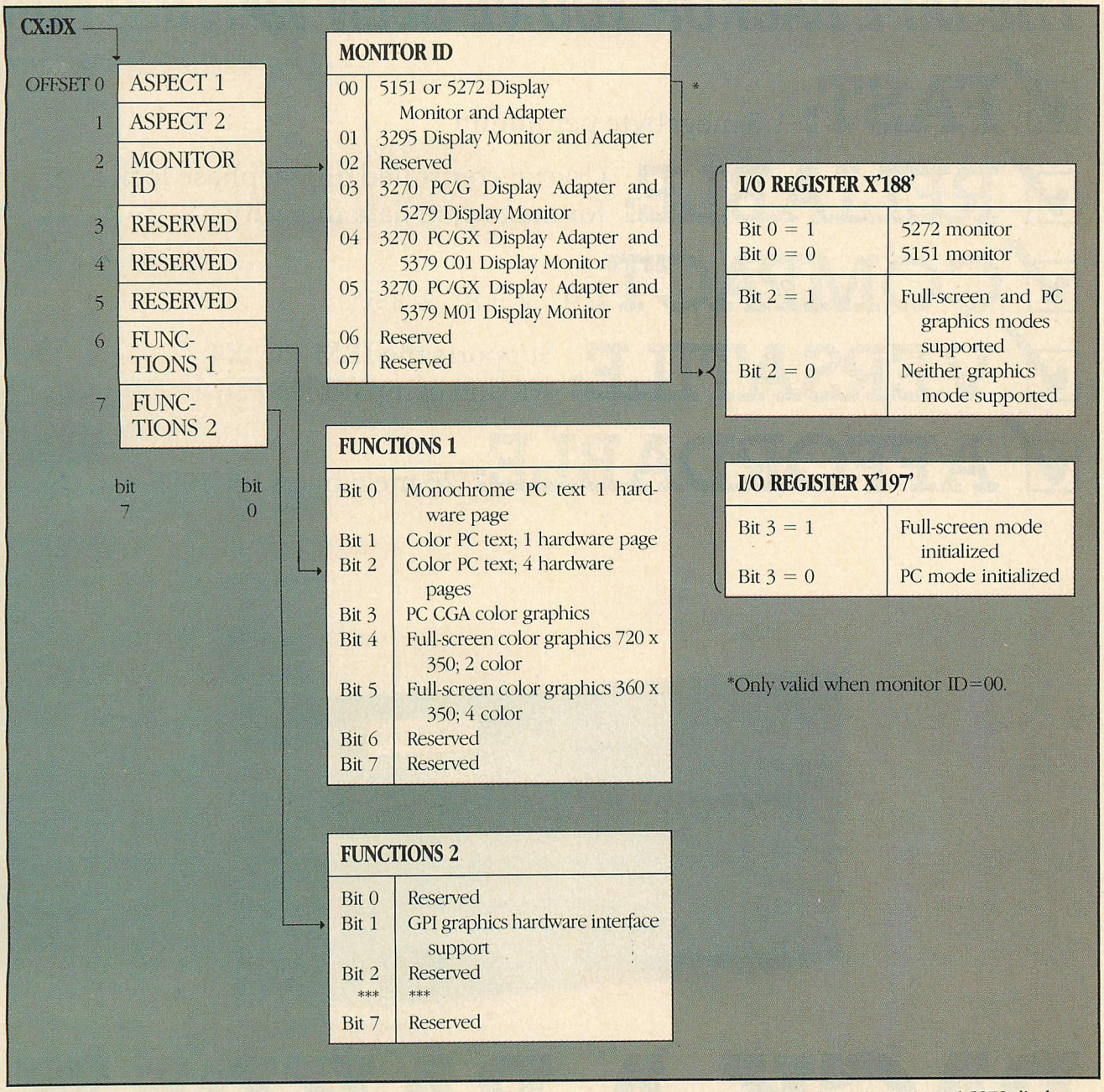
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FIGURE 1: *3270-PC Display Capabilities*



Once it is determined that the machine is a 3270-PC, additional testing may be performed to determine specific display capabilities that may be used on the machine, and for the 5151 and 5272 displays, the initialized mode.

even lines of the display buffer; and the full-screen mode.

In order to use the full-screen graphics mode, the application must initialize that mode of operation with the BIOS call INT X'10'. For medium-resolution mode (360-by-350, four-color), the AL register should be set to X'31'; for high-resolution mode (720-by-350, two-color), the AL register should be set to X'30'. In either case, the AH register should be set to 0.

In addition, the screen buffer is laid out differently from the PC. In PC-compatible mode, each scan line is 640 bits (80 bytes) long. The odd-numbered scan lines are in one memory location (buffer) and the even scan lines are in another. The 641st bit (81st byte) in the odd line buffer represents the next odd scan line on the screen.

Instead of the odd and even screen lines being in two separate blocks of memory, as it is in the PC, the full screen mode of the 3270-PC uses a single directly addressable 32KB block of memory for both the odd and even lines. The lines are arranged in order starting at line 0, and each line is 720 bits (90 bytes) long. So, bit 721 (byte 91) in the buffer is the beginning of the second line on the screen (line 1).

Applications that are sensitive to the aspect ratio of the display must make adjustments for the difference between the aspect ratio of the PC 5152 color display and the aspect ratio of the 5272 display. In medium-resolution mode, the 5152 has an aspect ratio of 5:6, compared to the aspect ratio of 35:27 for the 5272. In high-resolution mode, the aspect ratio of the 5152 is 5:12 compared to the 35:54 ratio of the 5272. This means that circles created by applications using the PC aspect ratios

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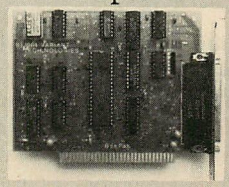
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FIGURE 2: *Color Comparison*

COLOR ATTRIBUTE CODE				PC COLOR	3270-PC COLOR
R	G	B	I		
0	0	0	0	Black	Black
0	0	1	0	Blue	Blue
0	1	0	0	Green	Green
0	1	1	0	Cyan	Turquoise
1	0	0	0	Red	Red
1	0	1	0	Magenta	Pink
1	1	0	0	Brown	Yellow
1	1	1	0	White	White
0	0	0	1	Gray	Black
0	0	1	1	Light blue	Blue
0	1	0	1	Light green	Green
0	1	1	1	Light cyan	Turquoise
1	0	0	1	Light red	Red
1	0	1	1	Light magenta	Pink
1	1	0	1	Yellow	Yellow
1	1	1	1	White (high intensity)	White

This conversion chart can be used to determine the 3270-PC color that will be obtained from the PC attribute codes. Only 8 of the 16 PC colors are available on the 3270-PC.

FIGURE 3: *Maximum Disable Time*

3270 PC CONTROL PROGRAM ENVIRONMENT

HOST ACTIVITY	OPERATOR ACTIVITY
None	Sizing window

PC APPLICATION ENVIRONMENT

ASYNCH BAUD RATE	MAXIMUM DISABLE TIME
300	25 milliseconds
1200	3 milliseconds
9600	500 microseconds

Even without host activity, the maximum disable time varies inversely with the duty cycle (interrupt rate) of the asynch adapter (the device being serviced here).

will appear as ellipses elongated in the horizontal direction when presented on the 5272 display.

The application may also dynamically determine the aspect ratio of the display and, thereby, determine if the screen is in medium- or high-resolution mode (see figure 1). The fields ASPECT 1 and ASPECT 2 identify the aspect ratio of the current graphics mode.

The application may use bits 0-2 of I/O register X'3D9' to select the background color in medium-resolution graphics mode. These same bits, however, may also be used in high-resolution graphics mode to determine the foreground color (the background color in this mode is always black).

The mode register X'3D8' on the PC is an output-only (write-only) register. The mode register of the 3270-PC may be both read and written. It is recommended that alterations to the mode register (as well as to any other bit-sensitive registers) be done by ANDing or ORing in the appropriate bit values.

Some PC applications modify the mode register directly without going through BIOS. When this is done the screen is not cleared, since the screen clearing function is done by BIOS. When the 3270-PC mode register is changed directly in graphics mode, the display refresh buffer will automatically be cleared by the 3270-PC microcode. This will cause the loss of all graphics data on the screen. Applications that are dependent on having the data remain on the screen while changing the mode register will have to be modified to rewrite the entire screen whenever the mode register is modified.

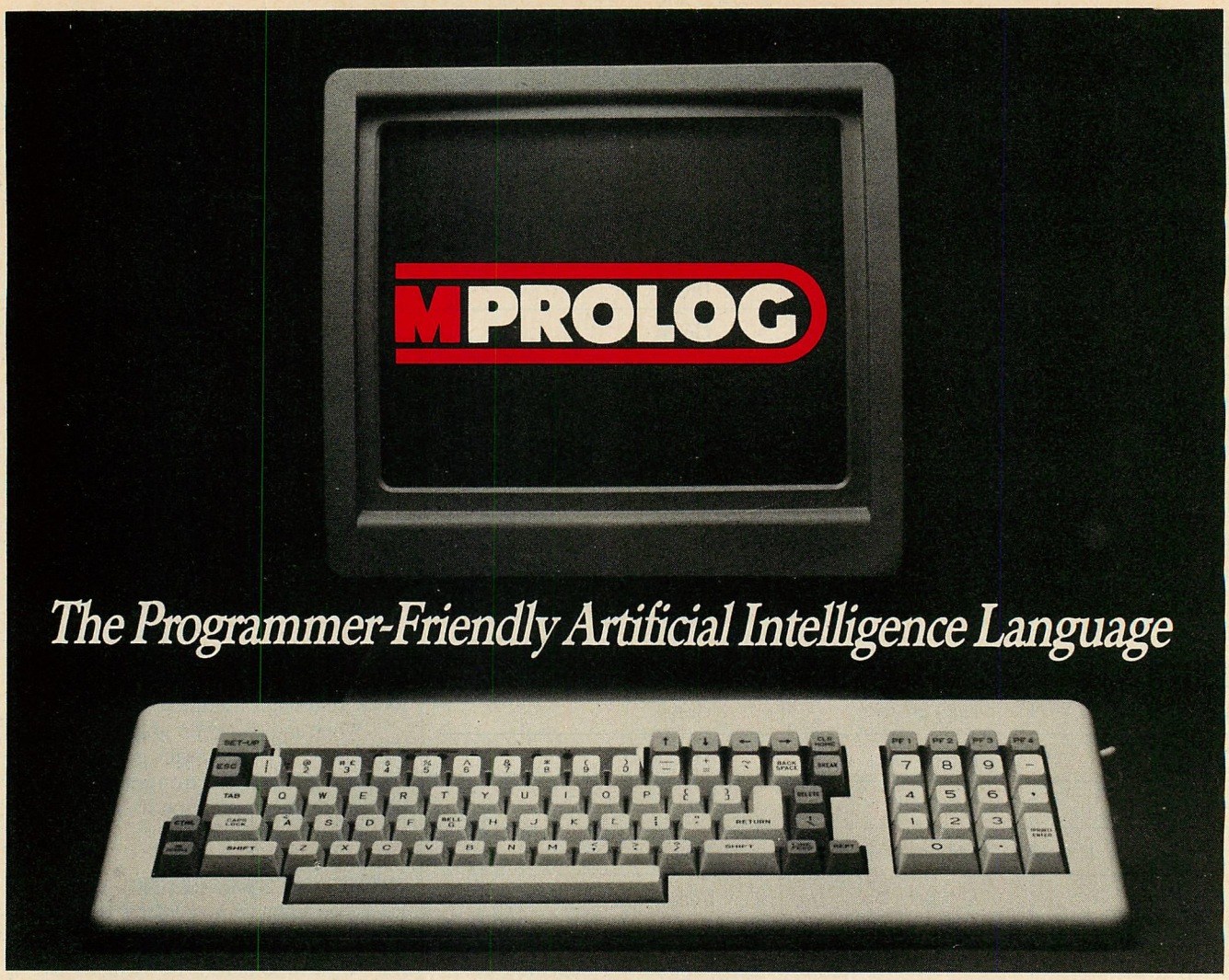
When in full-screen graphics mode, there is no BIOS character generator support. If characters are required in this mode, the application itself must provide the capability.

INTERRUPT PROCESSING

PC applications control interrupt usage (their ability to be interrupted at any point of execution) by enabling and disabling the 8088 processor and by sending instructions to the 8259 interrupt controller. The following guidelines assume an understanding of the 8259 interrupt controller and the use of PC interrupts in general.

The application must not attempt to reprogram, or otherwise alter, the 8259 interrupt controller. The 3270-PC reprograms the 8259 and is incompatible with other software that performs a similar function. Applications may enable or disable specific interrupt levels using the Interrupt Mask Register (IMR). Applications enabling and disabling specific levels should not store constants into the IMR since this will interfere with execution of the 3270-PC Control Program. Instead, the application should affect specific levels by ORing in and ANDing out data. This method will leave all the other levels of the IMR unaffected and thereby not interfere with the 3270-PC Control Program.

Applications programs must not use the cassette software interrupt because the 3270-PC puts this to special use. Additionally, applications dependent on NMI (nonmaskable interrupt) and printer interupts should be well tested in the 3270-PC environment.



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These interrupts are trapped and serviced by the 3270-PC Control Program.

The 3270-PC uses the interrupt vectors X'50' to X'57' and these vectors must not be alterted by any application running in the 3270-PC environment. All interrupts belonging to a PC application are rerouted to the appropriate PC interrupt levels. Applications that take over interrupt vectors must ascertain that any vector replaced ultimately must be invoked in a transparent manner.

Interrupts normally serviced at a specific hardware level may drop to level 7 if the interrupt is not serviced in time. This may occur in the PC; however, the timing considerations of the 3270-PC hardware may cause more frequent occurrences. This is important to know for applications that are sensitive to fielding all hardware interrupts at the 8259. Specific note should be taken for applications servicing a piece of hardware that does not interrupt repetitively, as loss of an interrupt may cause the device to be disabled, requiring a re-IPL of the system to recover.

Applications that take over timer interrupts are responsible for driving the timer interrupt vectors at the appropriate timing ratios. If the timer is taken over from another function that expects timer intervals of a specified length, it is the responsibility of the application taking over the timer to make certain that the timer events expected by other functions are not corrupted.

Whenever a PC application uses interrupts on the 3270-PC, it is competing with the 3270-PC Control Program for the CPU resources of the 8088 processor and for control of the system. If it does this without consideration for the control program's requirements, it may cause the control program to fail.

A program always gains control from a hardware or software interrupt in a disabled state. While the system is disabled, almost no other interrupt can take effect. It is obvious that if two programs are contending for the CPU resources of the system and one of these programs does not allow interrupts to occur, then the other program will never receive control in order to service its timing-dependent events. If this state were to continue for a very long period of time, the program not receiving control would most likely fail.

The amount of time that a PC application can run in disabled mode is dependent on a complex set of factors, including the transaction rate of the host applications and the interrupt rate of the device the PC application is servicing. In general, the design philosophy of any interrupt-driven application should be to keep the path length of the interrupt handler portion of the application as short as possible.

The following points are an attempt to give the applications developer a framework in which to design the application; however, the numbers stated below should be taken as maximum guidelines only.

Applications that gain control via a software interrupt must, within 25 milliseconds, enable all processor interrupts with an STI instruction, since a software interrupt masks all processor interrupts except for NMIs. Failure to enable interrupts within this time frame may cause a loss of interrupts and failure of the 3270-PC Control Program.

Interrupts that normally are serviced at a specific hardware level may drop down to level 7 if the interrupt is not serviced in time.

Applications that gain control via hardware interrupts must enable the 8259 interrupt controller (with an EOI instruction), re-enable interrupts (with an STI instruction), and return (with an IRET instruction) within 25 milliseconds maximum. Every attempt should be made to enable interrupts immediately upon receiving control or as soon as possible after servicing the device.

Of course, as the PC interrupt rate approaches or even exceeds once every 25 milliseconds, the path length of the interrupt handler in disabled mode will have to become significantly shorter than the 25-millisecond guideline. Likewise, as the host communications load increases, the allowable interrupt handler path length must decrease.

An example of how the maximum disable time must vary with respect to other factors is illustrated in figure 3, in which an asynch adapter is used as the device being serviced. It can be seen easily that, even without host activity, the maximum disable time varies inversely with the duty cycle (interrupt rate) of the asynch adapter.

A timing-sensitive application is one that must be active at a specific time in order to perform some function, such as servicing a specific event. Applications of this type (for example, dealing with devices that are highly timing-dependent, such as asynchronous communications adapters) require special consideration when executing in the 3270-PC environment. This is because the 3270-PC Control Program normally has (and expects to have) priority over the PC application. Whenever necessary, the control program will take control away from the PC application in order to service hardware actions important to the 3270-PC functions, such as hardware interrupts from the keyboard or the 3270 communications adapter.

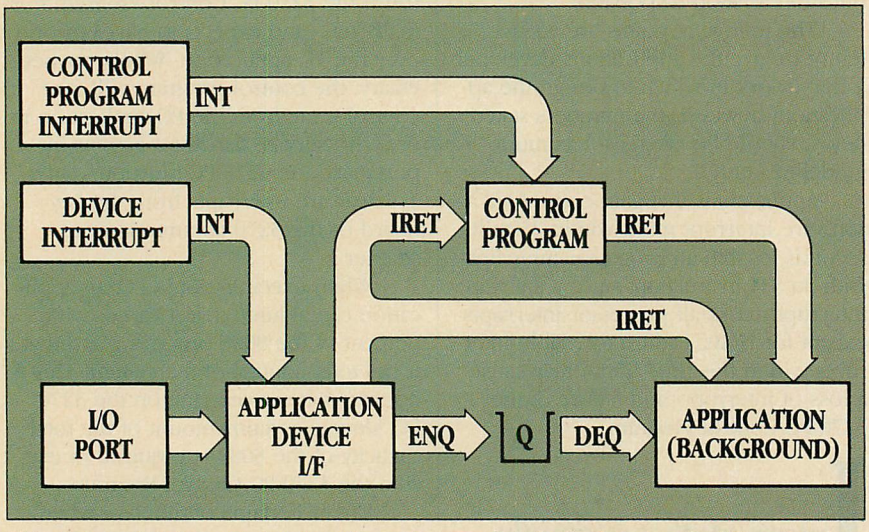
When executing on a PC, an application can assume that it can use 100 percent of the 8088 processor and that it has total control of the system. This is not true when executing on the 3270-PC, since a certain amount of the total capacity of the 8088 is required to execute the 3270-PC Control Program.

Under certain conditions—when 3270 host interactive session activity is high, for example—a PC application running in the background and polling the device it is servicing, may not be given control often enough to service an event on which it is dependent. This may cause the application to fail or produce erroneous results. It is particularly true of a program that assumes it is the only function running in the machine and attempts to service each device event completely as it is received.

The applications designer who is developing (or modifying) an application of this type to execute on the 3270-PC must take this operating environment into account. The concern, simply stated, is that when executing in conjunction with the 3270-PC Control Program, PC applications execution may be preempted at any time by a 3270 session interrupt. The time required to service that, and possibly subsequent interrupts, may be of such duration that control is not returned to the PC applications program until events are overrun at an I/O port it is servicing.

In order to reduce the possibility of overrun at the I/O port when servicing timing-sensitive devices, the application must be triggered when an important event occurs and take control from the 3270-PC Control Program. It must not just wait for the control program to give it control when 3270-PC session activity has finished. Timing-dependent applications, therefore, should use interrupts of some form (timer, asynch adapter) to drive the handling of data received from the device. Programs that are designed without an interrupt as a driving mechanism may operate and test out fine under normal 3270-PC operating conditions. Users should be watchful, however, for errors occurring under heavy load conditions.

FIGURE 4: *Segmented Device Handler Application*



This design minimizes data loss by using an intermediate buffer between the I/O port and the applications program to hold incoming data until they can be processed.

Driving an application using interrupts, so that control may be taken from the 3270-PC Control Program when necessary, may be done by adhering to the following procedure. If, however, the procedure is not adhered to precisely, other system-related problems may occur:

- The application's interface to the device being serviced should be triggered (driven) by an interrupt.
- The application should service the I/O port as quickly as possible with interrupts disabled. Under any circumstance, the maximum time allowed for this processing is 25 milliseconds including the EOI, STI, and IRET instructions. A number of factors (including host activity, operator interaction with the system and device duty cycle) can greatly reduce this maximum time. There will be cases in which the maximum allowable disable time will not be sufficient to process the data completely. In most cases, however, the maximum disable time is sufficient to queue the data for later processing in the normal background environment.

For applications that cannot process the input data in the maximum allowable period prior to enabling interrupts, the possibility of data loss can be minimized by incorporating a data buffer between the servicing of the I/O port and the processing of the data received. The application could be designed in two parts: a device interface portion and a data processing portion.

The application's device interface portion should be driven by the appropriate interrupt and its function should be limited to receiving the data from the I/O port, queueing the data to an input queue to be serviced by the background processing routine, enabling interrupts (EOI and STI), and returning to the system (IRET).

The data processing, or background, portion of the application should handle the normal processing of the data. This portion should be designed to acquire the input data from the intermediate buffer rather than directly from the I/O port. Since this portion will be given control whenever system functions of higher priority are not executing, there are fewer timing constraints on the processing of data. See figure 4 for a diagram of this design.

While this design prevents data loss at the I/O port, it cannot guarantee total freedom from data loss in the entire processing cycle because the intermediate data buffer itself may be overrun. This design, however, does minimize the possibility of data loss by having the intermediate buffer between the I/O port and the program that processes the data. As such, it is far superior to a design that attempts to process the data from the I/O port directly when extensive processing (more than 25 ms) must be performed for each event.

Timing-sensitive applications should be thoroughly tested in their intended environment. All such applications, if intended to execute in parallel with host activity on a 3270 session, should be tested in an environment with at least the maximum number of sessions and with transaction rates that approximate the maximum that will be encountered in the environment. Applications that may execute properly in parallel with 3270 session activity of low or moderate transaction rates, may not function at higher transaction rates.

Of course, if the PC application is not intended to run concurrently with the 3270-PC Control Program in a heavy host load environment, an interrupt-driven design for the application may not be necessary. This decision should be based on empirical data obtained from stringent testing performed in the application's intended environment.

The importance of adequate testing for 3270-PC applications cannot be overemphasized. This testing should take into account the environment in which the application will run. Users of the 3270-PC will expect to run their PC applications concurrently with host applications. It is not satisfactory, therefore, merely to test the application with the 3270-PC Control Program in memory. The application must be tested in an environment in which concurrent host application activity is occurring. The range of possible environments is very large and must be left to the applications developer to determine. If the environment cannot be adequately estimated, the developer would be wise to test his application in the most stringent environment possible, perhaps defining for his application the maximum host environment that will also allow adequate execution of the PC application.

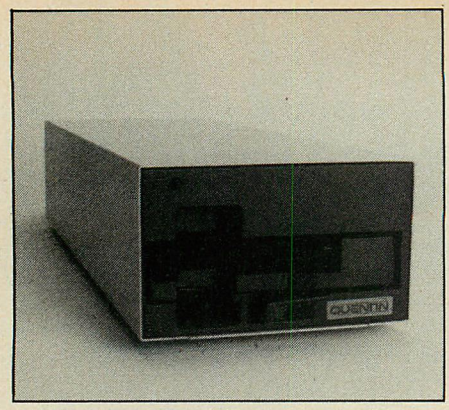
Any host communications problems will be due, most likely, to timing problems caused by a failure to adhere to the interrupt-processing guidelines. The applications developer should be aware that timing problems may not appear under all load conditions.

Experience has shown that many PC applications execute correctly on the 3270-PC without any modification. For most applications that do require modification, the changes are minor, and are usually due to one of the differences between the PC and the 3270-PC.

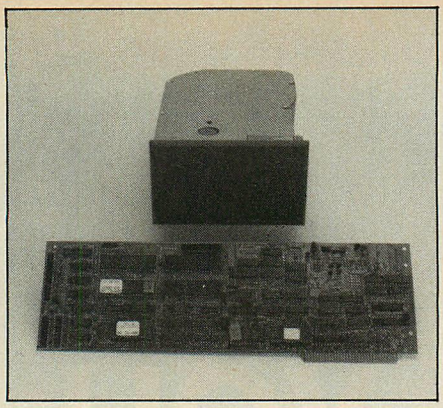
Programmers who are developing applications specifically for the 3270-PC will find that most PC coding practices and techniques will still be useful, as long as they are tempered with the guidelines presented here.

Armen Harian is an advisory programmer with IBM, where he has worked for 16 years. He is a graduate of the University of Rochester. Jeffrey Krantz is a staff programmer with IBM and coauthor of a book, 8088 Assembler Language Programming: The IBM PC. *He has a master's degree in computer science from the Polytechnic Institute of New York.*
The authors acknowledge the technical support provided by Tibor Panto and Dean Stockwell in the preparation of this article.

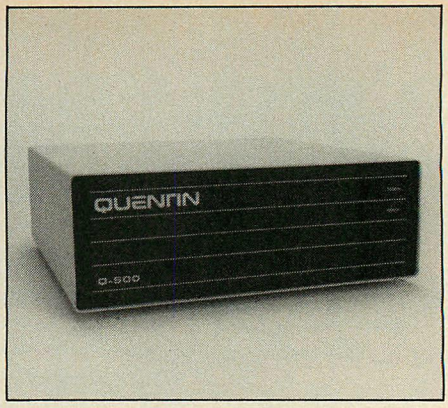
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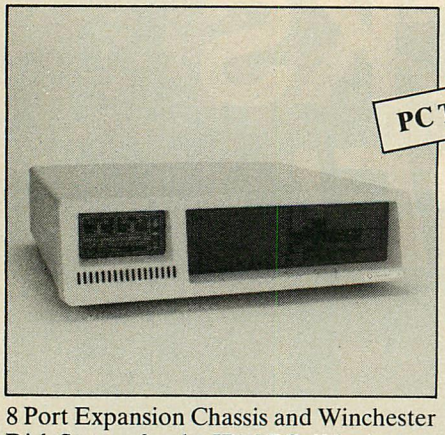
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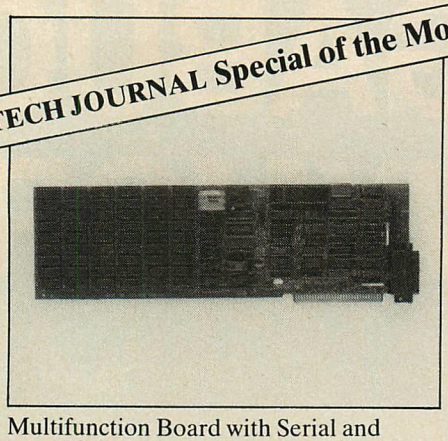
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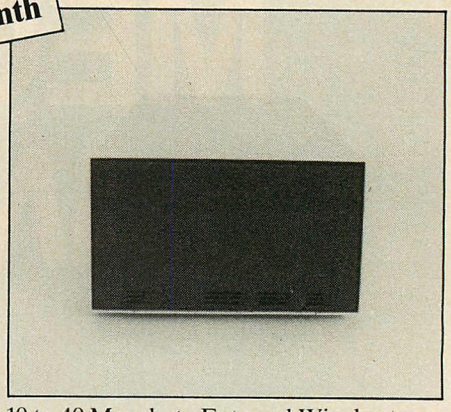


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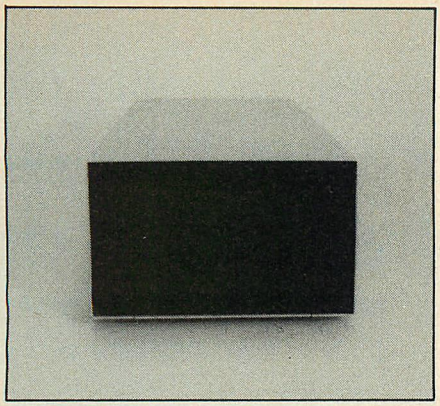
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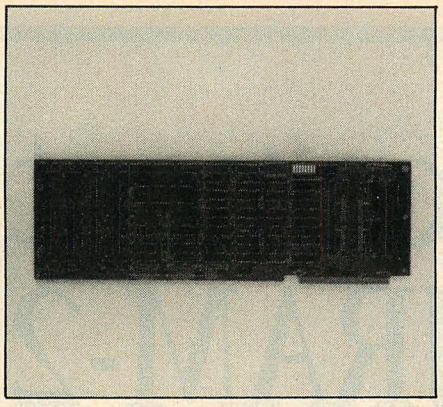
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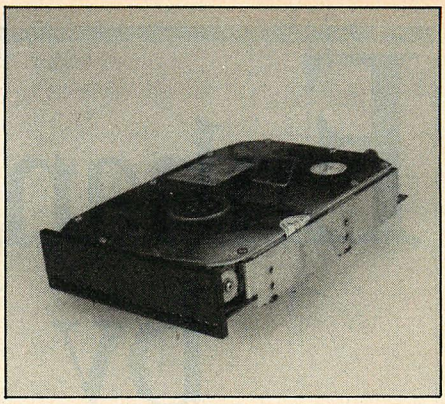
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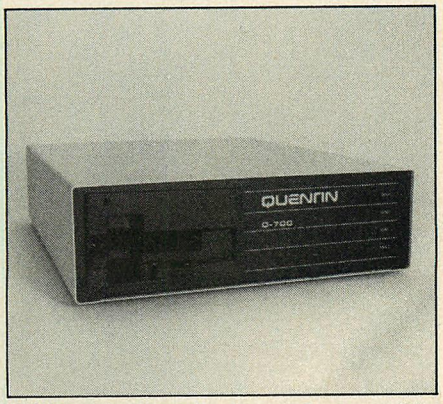
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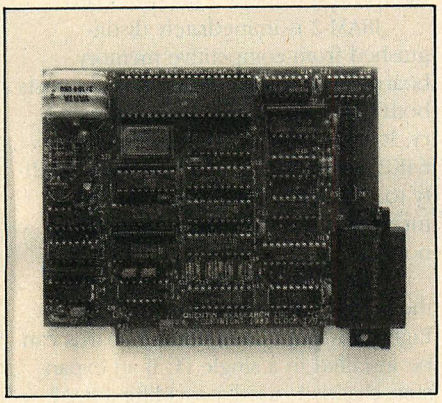
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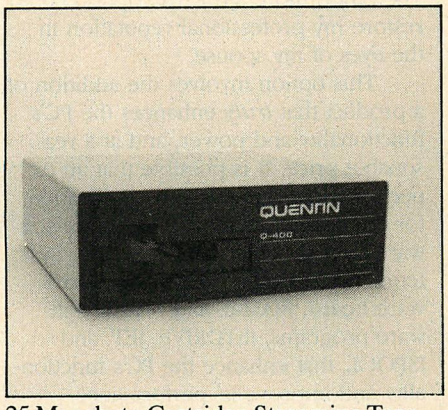
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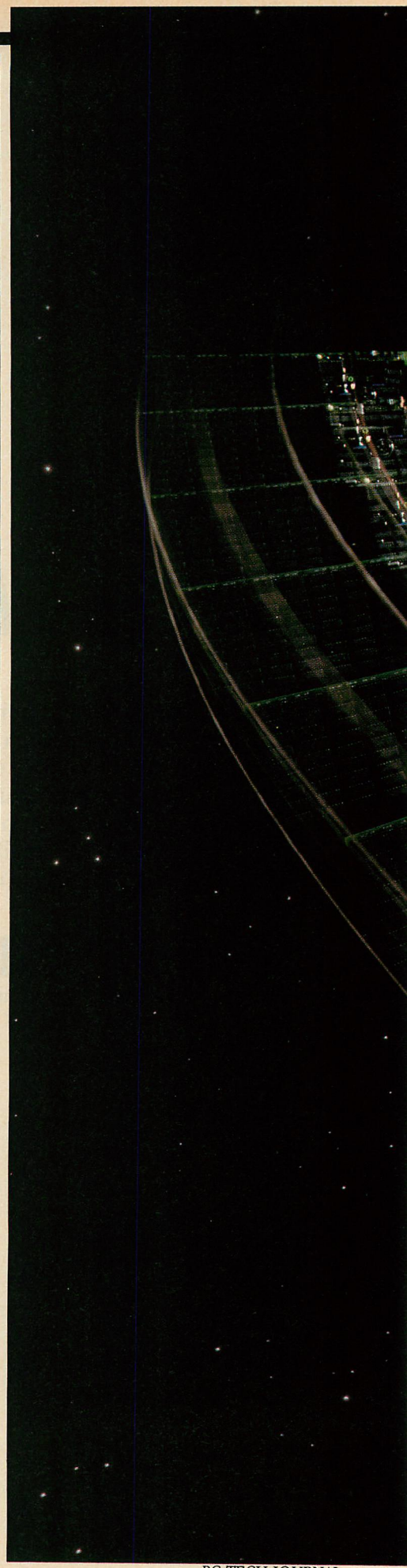
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Having staked my professional reputation with my wife on something I believed to be true—that the performance and versatility of the IBM PC would make it an essential addition to our "household of the eighties"—I was eventually forced to admit that the PC's power is not limitless, nor is the machine as versatile as I, at one time, had hoped.

Two solutions come to mind. I could, of course, say that it is simply time to move on to the sleek, shiny, new PC/AT, the power and versatility of which is impressive (it is unlikely, however, that I could sell *essential* again). The other, more attractive, option could restore my professional reputation in the eyes of my spouse.

This option involves the addition of a product that *truly* enhances the PC's functionality and power, and at a reasonable price. It is possible that an experience like mine was the motivation for the development of a hardware/software package created by Tall Tree Systems. The package consists of a hardware board, JRAM-2, and several software programs, JETDRIVE, JET, and JSPOOL, that enhance the PC's functionality and improve its performance.

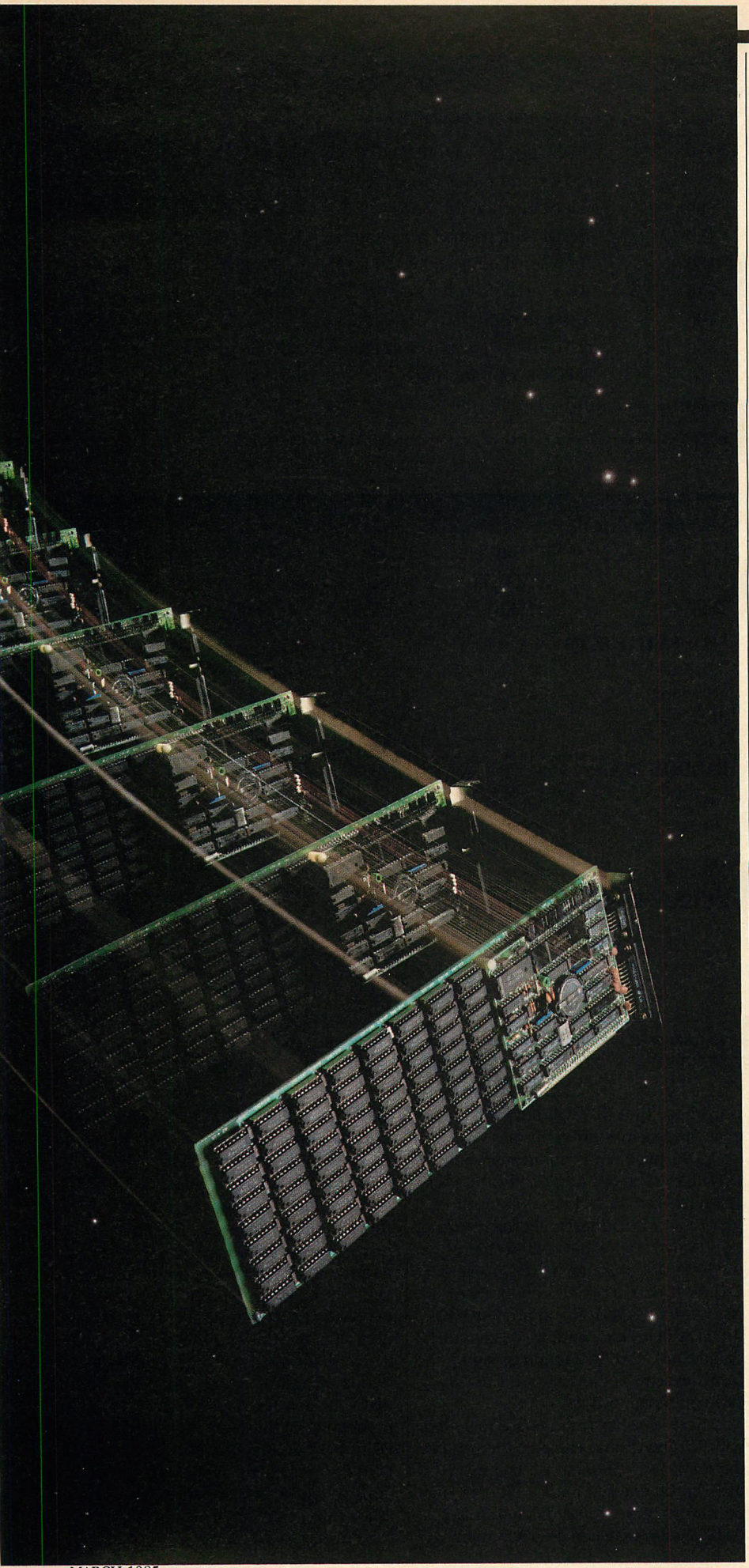
An introduction to the package begins with JRAM-2, a memory and multifunction board. JRAM-2 can be purchased with memory and any of the following options: clock/calendar, serial port, parallel port, and diskette controller. The board has a memory capacity of up to 512KB when populated with 64KB chips, and 2MB when populated with 256KB chips. One JRAM-2 board can have any combination of 256KB and 64KB banks installed.

The software, however, is the real power in this package. JETDRIVE, JET, and JSPOOL provide RAM disk, copy, and print spool capabilities that are in some ways faster and more versatile than the comparable software provided with MS-DOS. Table 1 gives the list prices for hardware and software. Hardware can be bought in several combinations; software can be purchased separately, even without a JRAM-2 board.

JRAM-2 is immediately distinguished from competitive memory boards by a unique design that supports both 64KB and 256KB banks of memory. It allows the use of less-expensive 64KB memory chips now, with the ability to switch to 256KB chips in the future when they become a more economical buy.

The JRAM-2 technology provides the PC with abundant memory capacity. Eight fully populated JRAM-2 boards can be installed in a single PC if an expansion chassis is used, providing a RAM disk of 16MB (using 256KB chips). Even if just one JRAM-2 board is used, the maximum 2MB capacity is superior to most memory boards.

The JRAM-2 board enables a large amount of memory to share the 1MB



address space in the IBM PC. This address space is organized into 16 "pages" of 64KB. Only 640KB is allocated to system memory; the remaining address space is reserved for display memory and ROM functions, such as BIOS, BASIC, and the Fixed-disk Adapter logic.

Software modification of a bank select register on the JRAM-2 board maps a 64KB bank of JRAM memory to a page of IBM PC memory. The JRAM software uses this addressing flexibility in three ways. First, banks of JRAM memory can be assigned addresses lower than 640KB and used for system memory expansion. Second, the normal system memory can be increased to 704KB by assigning a bank of JRAM memory to page 10. (System memory cannot exceed 704KB, because page 11 is used for display memory.) Third, multiple banks of JRAM memory can be accessed one at a time through a single page of PC memory when used as a RAM disk.

The bank select register consists of 16 locations that map each page to a memory bank on the JRAM-2 board. An invalid mapping code is used to prevent the assignment of a given page to a JRAM bank. Multiple banks of JRAM memory, each on a different JRAM-2 board, can be configured so that they respond to the same page address. Although reading from this page produces unpredictable results, writing to the page writes the same data to multi-

PHOTOGRAPH • WALTER WICK

ple JRAM memory banks simultaneously, a feature that holds potential for special applications.

Installation of the JRAM-2 board is easy, due, in part, to the concise documentation. The manual covers installation procedures, options, related technical topics, and a glossary of computer terms (found in all Tall Tree documentation). The documentation includes clear, informative technical write-ups on special cabling and serial hookups.

The absence of hardware switches, which must be manipulated to ensure memory is correctly addressed, contributes to the ease of installation. Switches are used only to address multiple JRAM-2 boards in a system. The switches on every JRAM-2 board come properly set for single-board configuration.

As an added note, the JRAM-2 board also operated properly on a PC/XT that was loaded with third-party products, including another vendor's multifunction board, with only one minor difficulty. The JRAM-2 board works well, indeed, but its companion software makes all the difference.

JETDRIVE is the RAM disk software that reserves a part of memory to simulate a disk drive and performs all driver functions required by MS-DOS. The use of RAM disks is different from that of traditional disk drives in three ways, two of which are advantageous, one of which is not.

The first advantage of a RAM disk is speed. A RAM disk is much faster than a floppy disk or even a fixed disk, as the benchmarking tests indicate. Any application that is disk I/O-intensive will run much faster if all the files it uses are transferred to the RAM disk first.

The second advantage of a RAM disk is capacity. Using eight JRAM-2 boards provides the potential for up to 16MB of memory available on a RAM disk: a higher capacity than the PC/XT fixed disk. And, although most users will not need all this capacity, a reasonable investment in memory permits the configuration of a 360KB RAM disk.

One caveat: the time required to perform RAM disk memory diagnostics can be lengthy. The Tall Tree memory diagnostic is faster than the IBM version, yet a test of 16MB of RAM disk adds *six minutes* to power-on time.

The one major disadvantage of a RAM disk is its potential to lose all saved information through a loss of power or an inadvertent reboot. Using the RAM disk requires some strict procedures: power-on the PC, copy all files to the RAM disk, do the work, copy all files to the hard disk, *then* power-off the PC. Better yet, copy to the RAM disk only those files that will not be changed, such as program files.

TABLE 1: *Price List*

PRICE	ITEM AND DESCRIPTION
$219	JRAM-2 board with JETDRIVE, JSPOOL, and JET (with no memory installed)
80	Clock function for JRAM-2
180	Serial port, parallel port, and clock for JRAM-2
180	Two serial ports and clock for JRAM-2
130	Two serial ports for JRAM-2
190	Diskette controller for JRAM-2
60	JETDRIVE software (purchased separately)
60	JSPOOL software (purchased separately)
60	JET software (purchased separately)

Tall Tree Systems offers a variety of options for the JRAM-2 board.

TABLE 2: *RAM Disk Performance*

TEST	JETDRIVE RAM DISK (128KB)	FIXED DISK (10MB)	FLOPPY DISK (360KB)	DOS 3.0 VDISK (128KB)
SEQUENTIAL READ (SECTORS)				
1 sector	.003	.022	.203	.003
8 sector	.011	.071	.357	.014
16 sector	.022	.126	.536	.019
24 sector	.033	.184	.673	.019
RANDOM READS—1 SECTOR (WIDTH SEEKS)				
.10	.001	.070	.110	.003
.33	.003	.111	.212	.003
.50	.003	.144	.236	.003
.90	.003	.214	.310	.003
RANDOM READS—8 SECTORS (WIDTH SEEKS)				
.10	.011	.118	.291	.014
.33	.011	.159	.393	.011
.50	.014	.190	.409	.011
.90	.014	.264	.492	.008

Both RAM disks perform with similar speed and outdistance disk storage media.

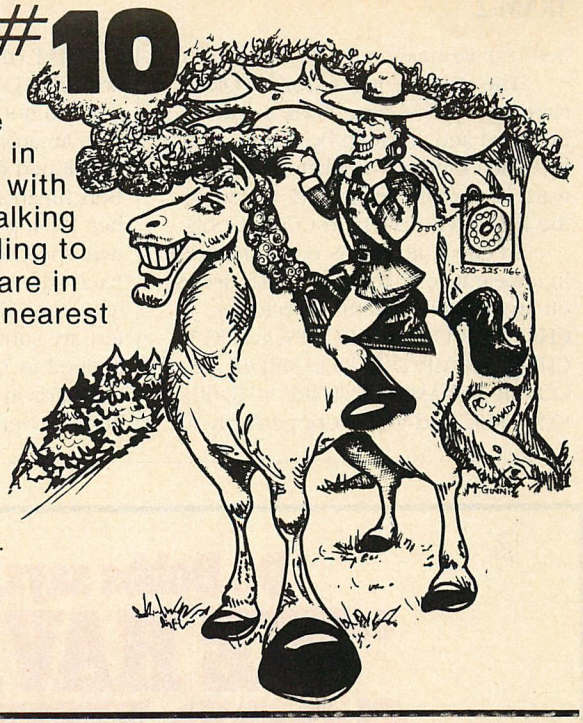
This problem is minimized with JETDRIVE. The RAM disk software intercepts the Ctrl-Alt-Del key combination, providing instead three alternative reboot functions: Ctrl-Alt-Del preserves the RAM disk through a "warm" reboot, Ctrl-Alt-K does a "cold" reboot that readies the RAM disk and powers-up the PC (including running the memory diagnostic), and Ctrl-Alt-minus-sign performs exactly as the standard Ctrl-Alt-Del combination does.

Several other features are included with JETDRIVE that enhance the use of the RAM disk. The first is a command that can be entered in CONFIG.SYS that permits memory to be divided in any combination between MS-DOS memory and a RAM disk. MS-DOS memory can also be defined up to 704KB, 64KB more than the PC standard.

Flexible memory resizing can be done at any time other than reboot, through use of the MAKEDOS command. The sizes of MS-DOS memory and the RAM disk can be freely modified, but making memory larger at the expense of the RAM disk may corrupt files already on the RAM disk.

A final, noteworthy JETDRIVE function is an ability to intercept parity and divide-by-zero errors. Normal MS-DOS processing of these errors causes the PC to hang until a reboot is done. JETDRIVE provides a prompt with directions to ignore, warm-start, or cold-start as a result of the error. Ignoring the error permits saving any work in progress

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before investigating the malfunction.

The documentation for JETDRIVE is superior. The 54-page book comes punched and ready to be put in an 8-by-9-inch binder. Installation of the software is carefully explained, including the JETDRIVE drivers in CONFIG.SYS.

In effect, JRAM-2 is nearly identical in appearance to the other disk drives on an MS-DOS system. Directories, CHKDSK, COPY, DISKCOPY, BACKUP, CHDIR, COMP, DIR, DEL, MKDIR, RECOVER, RENAME, RESTORE, RMDIR, SYS, TREE, and VOL work perfectly. FORMAT (disk is not DOS-compatible) and ASSIGN (unpredictable results occur) do not work on the RAM disk.

An automatic benchmark test, developed by William Hunt ("Fixed-disk Benchmarks," *PC Tech Journal*, November 1984, p. 64) was used to show the true speed difference between floppy, fixed (the one I used was a PC/XT type), and RAM disks. The results of this test are summarized in table 2. As explained in Thomas Hoffmann's speed comparison of ten fixed disks ("Ten by Ten," November 1984, p. 52), the sequential read speed varies based on rotational speed of a disk; the random read speed shows either the impact of rotational speed of the disk (for short random reads), or the combined impact of seek time and rotational speed (for longer random reads).

The RAM disk has no seek time or rotational speed because it is not a mechanical drive. The times shown in table 2 reflect the time taken by the RAM disk software driver to access data on the RAM disk.

Some remarkable speed differences between RAM disks, fixed disks, and floppy disks are evidenced. For random reads of one sector, RAM disks are up to 100 times faster than floppy disks and 70 times faster than fixed disks. For random reads of eight sectors, where maximum head travel is required on a mechanical disk, RAM disks are 35 times faster than floppy disks and 19 times faster than fixed disks.

The RAM disk can be made even faster than the benchmark tests showed by using faster memory chips on the JRAM-2 board. Tall Tree uses memory chips with 275 nanosecond (ns) access time, compared to IBM PC memory, which has an access time of 210 ns. (PC *Jr* and PC/AT use 150 ns chips.) In the case of RAM disk, the speed improvement over fixed disk is so tremendous that this trade-off seems to make sense, but the cost of memory is dropping so quickly that there soon may be little difference between the cost of 150 ns and 275 ns memory chips.

The second software program provided by Tall Tree is probably the most powerful of the three. JET combines the best features of COPY, DISKCOPY, and BACKUP and adds some features that are absent under MS-DOS.

Table 3 shows a comparison of JET with COPY and DISKCOPY. JET resembles COPY more than DISKCOPY, yet performs additional functions such as copying hidden files, subdirectory names, and volume labels.

JET is a powerful tool for archiving files. If a disk contains many files that are modified periodically, JET can be used to copy onto a disk only those files that have been modified since the last archive operation. JET can also be used to copy only those files that exist on the target diskette.

Also provided is the capability to mix and match the features shown in table 4. For example, files can be listed as they are copied, and files can optionally overwrite duplicate files on a target disk. JET command strings can easily create complex copying functions. These sophisticated copying functions

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TABLE 3: *JET Versus COPY Versus DISKCOPY*

FEATURE	JET	COPY	DISKCOPY
Single File Copies	Y	Y	N
Multiple File Copies	Y	Y	N
Wildcard Use	Y	Y	N
Lists Files Transferred	Y	Y	N
Renames Files Transferred	N	Y	N
Checks For Bad Tracks—Target	Y	Y	N
Copies Single to Double Sided	Y	Y	N
Quad-Density Support	Y	Y*	Y*
Hard-Disk Support	Y	Y	N
Can Format	N	N	Y
Back up to Multiple Disks	Y	N	N
Back up since Time/Date	Y	N	N
Back up only if File Exists on Target	Y	N	N
Copy Volume and Subdirectory nameS	Y	N	Y
Selective File Erase	Y	N	N
Copy Hidden Files	Y	N	Y
Copy BOOT SECTOR	Y	N	Y
Copy Using File List	Y	N	N
Copy changed Files Only	Y	N	N

* MS-DOS 3.0 only

JET software offers many enhancements not provided in DOS's COPY or DISKCOPY.

are not available with MS-DOS.

JET supports more functions than DISKCOPY as well. It supports hard disks and RAM disks, checks target disks for bad tracks, and copies from single-sided to double-sided disks, features not found with DISKCOPY. In addition, DISKCOPY does not support the ability to back up to multiple disks (like BACKUP), as JET does.

Similar to BACKUP and RESTORE, JET possesses the capability to copy a file or a set of files to and from multiple disks. JET can also back up hard disks, although it cannot back up more than one subdirectory per JET command. Any fixed disk that is set up with a large number of subdirectories cannot be easily backed up with JET.

JET features other advantages over BACKUP. The format of the files backed up by JET is MS-DOS, whereas files written by BACKUP have nonstandard file allocation table definitions. If back-up files are in an MS-DOS readable format, their use is not predicated on RESTOREing them to another disk beforehand. (However, the program BACK1 in the new IBM Utilities II package is a simpler version of BACKUP that creates files in MS-DOS format.)

One weakness with JET is that it does not recognize the current directory; a full pathname is always required. If no pathname is specified, the default directory for a file is the root directory, not the current directory. This takes some getting used to, and the extra keystrokes on command lines can be laborious. Nor does JET seem to be as fast as Tall Tree claims. The documentation says that JET is much faster than COPY. Tests revealed that in multiple file copies, JET was identical in speed to COPY, while in a single, large-file copy (512KB), JET was much slower (21 seconds compared to COPY's 12 seconds).

In most cases, back-ups using JET will require more diskettes than PC-DOS's BACKUP command. This is because files from multiple subdirectories should not be backed up to the same diskette if they are to be restored to unique subdirectories. A back-up of a single subdirectory will use less diskette storage with JET than with BACKUP, which adds 128 bytes to each file.

Despite these minor drawbacks, JET deserves serious consideration. The utility of some creative JET command strings to enhance the PC's copying ability should not be underestimated.

A weak link in an otherwise sound package, JSPOOL performed poorly under a fairly rigorous review, with unstable program operation and weaknesses in its documentation. Fortunately, JSPOOL is included free, and therefore does not adversely affect my recommendation on the purchase of the package as a whole, but I cannot recommend it for separate purchase.

JSPOOL is a print spooler. Since the PC sends characters to the printer much faster than they can actually be printed, any print operation results in

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the PC waiting for the printer to catch up. JSPOOL and the print spool area are used to buffer received characters from the PC and to supply characters to the printer as necessary.

The JSPOOL software intercepts characters that are sent from the PC to the printer by replacing INTerrupt 17 (line printer interrupt) and by looking like a printer to the PC in terms of status returned. JSPOOL then sends characters to the printer whenever the PC's internal clock interrupt is given control (about 18.2 times per second, or every 55 milliseconds). Through this process, JSPOOL permits the PC to be used for other operations, while printing is done in the background.

JSPOOL software creates the print spool area and provides special commands to manage the spool buffer. These commands allow printing to be suspended and resumed, flushing of the spool buffer, and partial document printing, a feature not included in the MS-DOS PRINT command. JSPOOL also offers the capability for special printing modes on the more popular printers.

Another function of JSPOOL is regulation of the amount of CPU time dedicated to the background printing task. This function defines the amount of time that JSPOOL uses when sending characters to the printer as part of the PC's internal clock interrupt. The time allocated to printing can vary from one character per second to the maximum speed of the printer, with the PC dedicated to the print task until completed.

Two other programs, JTYPE and MAKEFILE, are included with JSPOOL. JTYPE is similar to the MS-DOS PRINT command, yet it can print to the screen, to the printer, or to both simultaneously. JTYPE has a nice screen-dump feature that automatically pauses when the screen is full; pressing a key displays another screen of information. MAKEFILE is a utility that enables a spool buffer to be created in memory, RAM disk, diskette, or fixed disk.

Now for the disappointments. The JSPOOL manual compares poorly with the excellent JRAM-2 and JETDRIVE/JET manuals. It is poorly organized, inaccurate, and not written for the first-time user. For instance, the documentation was unclear on configuration of the print spool data area on the RAM disk as a predefined file. Attempts to set up a file on the RAM disk were fruitless; after many tries, it became obvious that JSPOOL cannot operate without a print spool buffer created in memory when the system is rebooted. To maximize memory by putting a spool buffer on a RAM disk, a very small spool buffer

TABLE 4: *JET Functions*

JET A: B: A:FILENAMES/F
Copy all files named in a text file

JET A: B: A:FILENAMES/T
Copy all files *except* files named in a text file

JET A: B:/E/B/O
Erase all files on a disk, copy all disk files, make target a bootable disk

JET A: B: A:FILENAMES/F/I020185
Copy all files named in a text file that have been created or changed since a given date (2/1/85)

JET A: B: A:FILENAMES/F/I020185/K
Copy all files named in a text file that have been created or changed since a given date (2/1/85), and reset archive attribute bit to zero

JET A: B: A:FILENAMES/F/J
Copy all files in a text file that have had their archive bit changed (meaning the file has been written)

JET A: B: A:FILENAMES/T
Transfer all files except the ones in the file list

JET A: B:/P
Display all the files on A: that are not present with the same time and date on B:

JET A: B:/P/U/I020185
Display all the files on A: that are dated 2/1/85 or later and are present with any date on B:

JET A: B: A:FILENAMES/F/E/D
Erase an old diskette, and transfer all files from a file list

The JET software provides many options for enhanced flexibility in file transfer and archive operations. Sophisticated and complex command strings can be constructed with these functions, as shown in the above examples.

(1KB) must be created in memory, which then permits the use of an additional large RAM disk spool buffer.

JTYPE is also poorly documented. Features of this program are not consistent with the on-line help facility. The program was made functional, but with little confidence in its use.

Other instances occur in which commands are described in the main body of the text but not included on the Quick Reference Sheet, and in which commands show up on the Quick Reference Sheet but are not described in the text.

JTYPE has operational problems. Several times, when output was inadvertently directed to the printer and screen, Ctrl-Break was pressed to abort, which caused the PC to reboot. Another similar experience occurred when a word processor was in use. After printing a document (which was intercepted by the JSPOOL software and spooled), the word processor was exited. The system rebooted again.

These shortcomings cause JSPOOL to be a subpar product despite some advanced features. Perhaps a future release will clean up the documentation and software. In the meantime, the availability of the MS-DOS PRINT command is suitable for most needs.

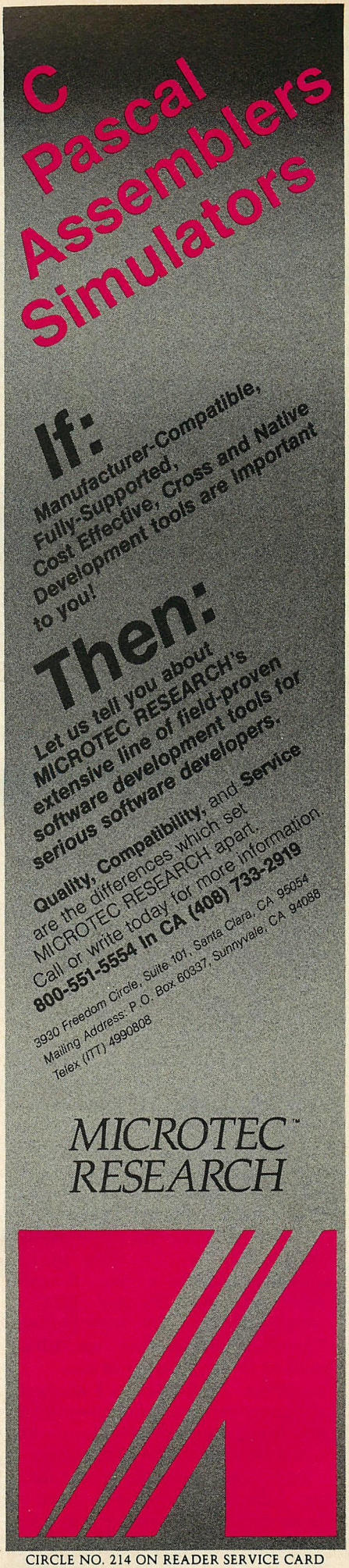
The rest of the software and JRAM-2 up are first class. The package works with MS-DOS versions 2.0, 2.1, and 3.0 (Extensive testing was done with MS-DOS 3.0.) Tall Tree even supplies *source* for its software drivers, providing users with the opportunity for, in IBM's words, "clever programming."

It is clear that Tall Tree put a lot of thought into this product. There are few opportunities to buy a good hardware board such as JRAM-2 and receive a free set of superior software as well.

Now if only my wife agrees.

JRAM-2
(see table 1 for prices)
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415/964-1980

Don Awalt is in systems engineering management at EMC Controls. He is the author of Hellcat Ace, *by MicroProse Software.*

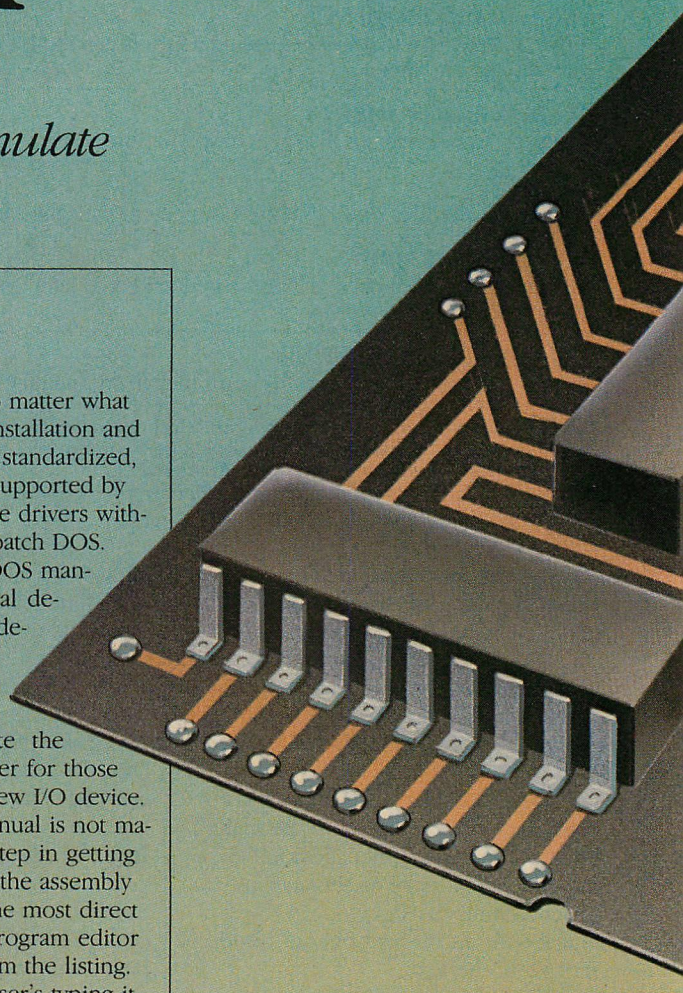


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Spinning Your Own VDISK

A program in the back of the DOS manual uses a portion of RAM to emulate a diskette drive.

ED NISLEY



A free offer is something few people will pass up, but some may pass by one without being aware of it. Users who have bought DOS 2.0 (or later) for their PCs and have not looked in the back of the manual are missing out on one such offer. Tucked away in the section dealing with device drivers, users can find a little gem of a free program: a "virtual" diskette drive called VDISK.

VDISK uses a chunk of the PC's RAM to emulate a diskette drive, yet, unlike a real drive, VDISK is blazingly fast and absolutely silent. However, because RAM is volatile, when the PC is turned off, any information stored on VDISK will vanish.

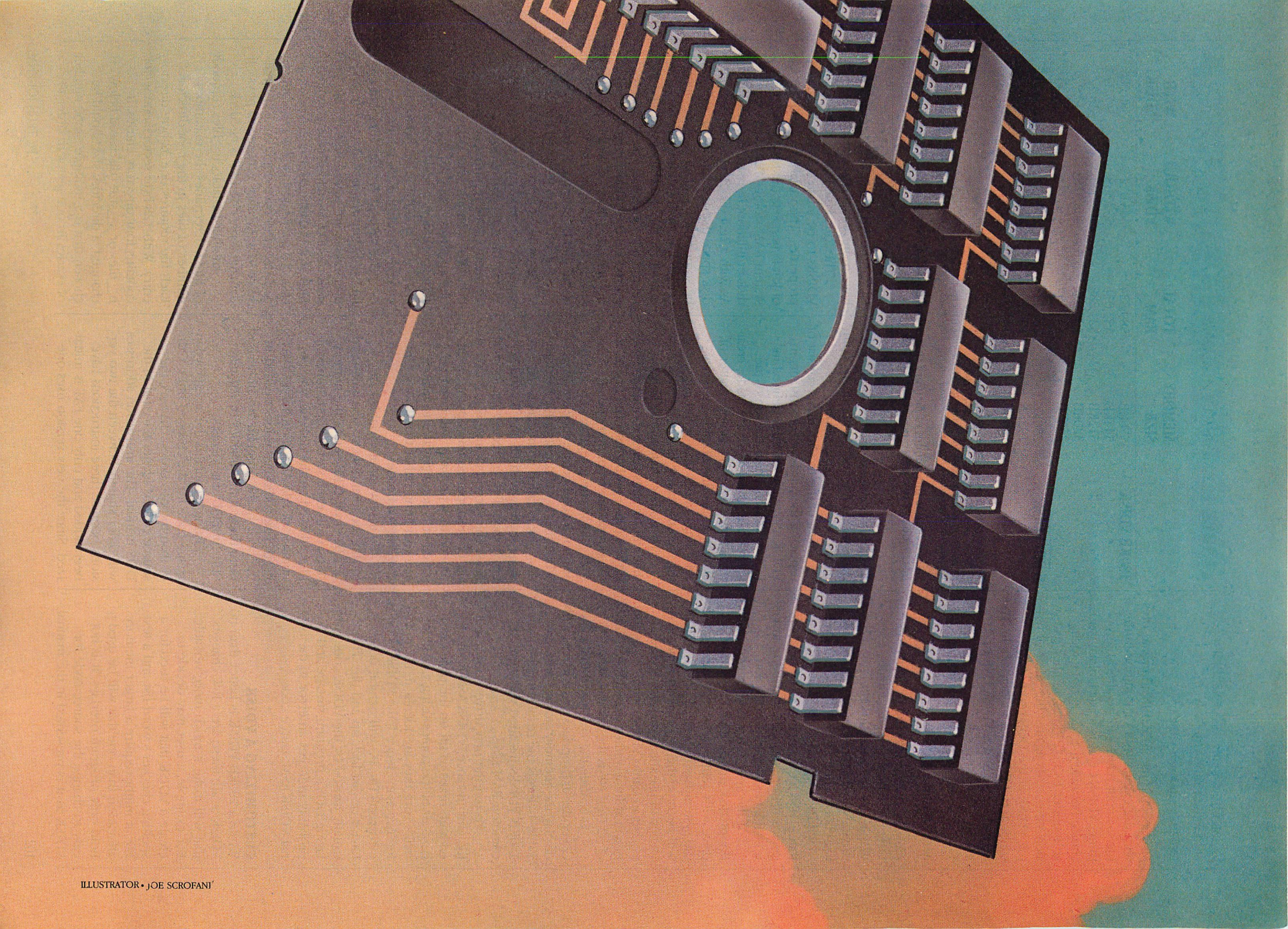
The listing in the back of the manual can be transformed into a real program with a few modifications to make it more useful. An editor will be required to create the source file, along with the IBM Macro Assembler, DOS Linker, and EXE2BIN to create the executable program, and at least 256KB of storage (more would be better) to use it. Users should remember that VDISK works only with DOS 2.0 or later.

Neither DOS 1.0 nor 1.1 supplied a structured way to support a new I/O device. DOS 2.0 solves this problem with *installable device drivers:* DOS extensions installed during the boot initialization. A device driver contains all the I/O device control code and presents a standard interface to DOS no matter what the device is. Since the installation and use of device drivers are standardized, new I/O devices can be supported by simply writing new device drivers without figuring out how to patch DOS.

One section of the DOS manual discusses the technical details involved in writing a device driver. The source code for VDISK is included as a "Sample Device Driver" to illustrate the structure of a typical driver for those who need to support a new I/O device. Since the code in the manual is not machine-readable, the first step in getting it working is to generate the assembly language source code. The most direct way is to use a favorite program editor and type it in directly from the listing.

One benefit of the user's typing it in is that he will have a better idea of its contents, making later modifications easier. If someone else's source is used, it should be checked for modification. Several different programs have appeared on bulletin boards, all of which use the name VDISK. The starting point for each individual probably should be the program in the DOS manual—just beware of substitutes.

Once the code has been compared against the published listing, it can be installed. Use the LINK.EXE to create VDISK.EXE from the assembler's



ILLUSTRATOR • JOE SCROFANI

VDISK.OBJ. Finally, use EXE2BIN to create the output file:

```
EXE2BIN vdisk.exe vdisk.sys
```

Most people use EXE2BIN to create files with the extension .COM. Although this file's output name can be almost anything, VDISK.COM is a particularly bad choice because the file is *not* executable under DOS. Picking another extension safeguards against the error of typing VDISK at the DOS prompt and sending the PC off into a black hole. To be even safer, erase VDISK.EXE once VDISK.SYS is created.

Next, the following command

```
device = vdisk.sys
```

must be placed into the CONFIG.SYS file on the boot diskette. Finally, copy VDISK.SYS onto the diskette, put it into drive A:, and press Ctrl-Alt-Del in order to reboot. Then DOS will read CONFIG.SYS during the boot operation, discover that VDISK.SYS contains an installable device driver, and will, therefore, install it in RAM as a system extension.

If the system has one or two real floppy disk drives, it will now have a C: drive with 180KB of storage capacity. If the system has three real drives, VDISK will become the D: drive. In general, DOS will use the next letter in the alphabet to name VDISK, with "Z" as the practical limit, rather than the real limit of 32 (not 64 as the manual states).

Executing the command CHKDSK C: (or the appropriate drive letter) will display the memory storage allocation. Table 1 details the results for 64KB and 180KB VDISKs installed with several common RAM sizes.

To test the new drive, copy a text file (for instance, VDISK.ASM) onto C: enough times to fill up the disk. Compare all of the copies using COMP to make sure they are identical; if any difference is evidenced, the VDISK code is incorrect. The PC will exhibit odd behavior or just lock up and die. This is usually caused by the VDISK code overlaying DOS's program storage and probably indicates an error in the original VDISK.ASM source code.

TABLE 1: *System RAM Available*

	MEMORY SIZE	TOTAL RAM	WITHOUT VDISK	WITH VDISK
180KB VDISK	576KB	589,824	565,072	380,000
	544KB	557,056	532,368	347,296
	512KB	524,288	499,600	314,528
	320KB	327,680	302,928	117,920
	256KB	262,144	237,391	52,384
64KB VDISK	256KB	262,144	237,391	171,168
	192KB	196,608	171,856	105,632
	128KB	131,072	106,320	40,095

No other DOS extensions were installed.
DOS 2.0 occupies about 24.2KB in all cases.
In addition to the VDISK's basic size, the VDISK program requires about 700 extra bytes.
Variations of about 64 bytes were found on repeated trials, with no apparent significance.

Shown here is the amount of memory that is available to applications programs after the installation of two different sizes of VDISKS.

CUSTOMIZING A VDISK

While a 180KB VDISK is better than no VDISK at all, there are a few changes that will make it much more versatile. For example, a user may decide to create a VDISK that will be used for a spelling checker's word list and a text file; it might require a larger memory allocation than one that will be used to hold only program overlays. It is not easy to change the source code for VDISK as it is presented in the manual: several important constants are buried deep within the code, without any comments or other explanations.

Most of the modifications consist of replacing the hard-coded constants in VDISK.ASM with variables defined in EQU statements near the top of the source file. Once these are made, creating a new VDISK is a simple matter of changing one line of code (and reassembling) rather than searching through the entire file.

Two other changes can be made that will fix bugs (even though the bugs do not cause problems). The first is at the device interrupt entry point (dev_int), where registers ES and BX are not loaded before they are used. While this is not catastrophic because dev_int is called immediately after dev_strategy with ES and BX still set up, it should be corrected just for neatness. The second change is just after the list of unsupported entry points; even though they probably will never be called, it is good practice to include a safe exit jump rather than falling into the disk read code.

Four new input variables are found: the total diskette size measured in 1,024-byte (1KB) units, the number of bytes in each sector, the number of files allowed on the diskette, and the number of File Allocation Tables (FATs) used. The additional values needed in the body of the program are all derived from these four variables by calculations in EQU statements.

Listing 1 contains the assembly language code for the changed lines. Other than the two dozen changes, the source code is identical to that in the DOS manual. The instruction addresses will differ slightly between the two versions because three instructions have been added and only one FAT is initialized. Since the new version uses one FAT and has a smaller directory, it will have more initial space available.

The four new input variables allow VDISKs to be created with specific properties. The variable n_k (number of kilobytes) sets the total amount of system RAM storage reserved for the disk emulation, measured in 1KB units. As with a real disk, the actual amount of disk space that is available for files will be somewhat less than n_k because a certain amount of disk space is required for the directory, FATs, and the reserved boot sector. The storage required for the VDISK program itself is not included in n_k, so the amount of system RAM dedicated to VDISK will be about 700 bytes more than n_k.

Since the storage used for the VDISK is taken from the RAM that is available for programs, the size of the VDISK must be traded against the amount of RAM required for applications. For example, the Macro Assembler requires about 96KB of storage; if a 180KB VDISK is installed on a 256KB system, only 76KB is left, which is not enough to run the assembler.

The variable n_fats (number of FATs) determines how many File Allocation Tables are stored on the disk. DOS uses the FAT to map disk sectors into files; if it is damaged, the disk is unusable. To guard against this possibility, real diskettes have duplicate FATs, but since VDISK is not exposed to physical damage, only one FAT is needed.

Another variable, n_files (number of files), determines the maximum number of files in the root directory. Each file requires one 32-byte directory entry. With 128-byte sectors, one sector contains four directory entries. If n_files or s_size (discussed below) is changed, a directory size should be chosen that is a multiple of the number of entries in one sector in order to

eliminate unused space in the directory sectors. For example, one 512-byte sector will hold 16 directory entries, so n_files should be a multiple of 16.

S_size sets the number of bytes in each disk sector. Although all IBM PC diskettes and fixed disks use 512-byte sectors, any reasonable number can be chosen for a customized VDISK. The guidelines are simple: the number must be a power of two, it cannot be bigger than 1,024, and it should not be less than 128. This allows a choice of 128-, 256-, or 1,024-byte sectors.

Decreasing the sector size by reducing the value of s_size will reduce the number of bytes wasted at the end of each file and thus increase the usable amount of space on the disk. This is true because, unless a file's length is exactly divisible by the number of bytes in a sector, some bytes will be left unused in the last sector of the file. For instance, a 540-byte file on a VDISK with 512-byte sectors will require two sectors; 484 bytes are wasted in the last sector. With 128-byte sectors, five sectors are needed, but only 100 bytes are wasted in the last one.

On the average, about half of the last sector is wasted for each file on the disk when estimating the loss. If 20 files are put on a VDISK with 512-byte sectors, about 5,120 bytes will be wasted; with 256-byte sectors, the loss is halved to 2,560 bytes; at 128-byte sectors, it's down to 1,280 bytes. It would appear that the smaller the sector, the better.

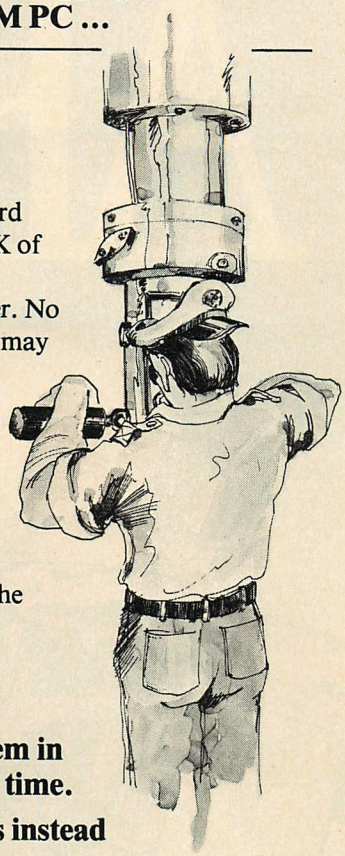
However, reducing the sector size in a VDISK of a given size increases the total number of sectors, which increases the size of the FATs. The exact number of bytes in a FAT is given by 1.5 * (number of sectors), but, as with all files, if that number is not an exact multiple of the number of bytes in a sector, some bytes will be unused in the last sector.

Smaller sector sizes increase the size of the FAT but simultaneously reduce the wasted space in the last sector of each file, which seems fair on the surface. A 180KB VDISK, for example, with 512-byte sectors has 360 sectors, so one FAT occupies 540 bytes. This will require two sectors and thus occupy 1,024 bytes. Using 256-byte sectors increases the FAT to 1,280 bytes and 128-byte sectors tie up 2,176 bytes.

One major restriction not stated explicitly anywhere in the DOS manual, but that can be inferred from the information about the FAT, is the limit to the number of sectors that can be placed on a diskette. The limit is based on the size of a FAT entry, which is 12 bits (1.5 bytes). Since each FAT entry maps one allocation unit (or cluster) on the

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TABLE 2: *VDISK Storage Capacity*

NOMINAL CAPACITY		ACTUAL CAPACITY		REMAINING CAPACITY	
		128/sector	512/sector	128/sector	512/sector
64KB	(65,536)	63,616	63,488	27,008	25,088[1]
128KB	(131,072)	128,384	129,024	6,016	2,560[2]
180KB	(184,320)	180,922	181,760	58,624	55,296[2]
360KB	(368,640)	363,136	365,568	240,768	239,104[2]

Files were obtained from:
[1] BASIC files from DOS Supplemental Programs diskette
[2] All files except IBMBIO.COM and IBMDOS.COM from DOS 2.0 distribution diskette.

The actual capacity of a VDISK is less than the amount of memory reported. The remaining capacity of the VDISK is determined by the amount of storage left after copying the specified files onto it. In general, 128-byte sectors are more practical for smaller VDISKs.

diskette and VDISK has one sector per cluster, no more than 4,096 sectors can be on the diskette. FAT values 000h and FF0h through FFFh are reserved for special purposes, leaving only FEFh values for sector mapping. Therefore, at most, 4,079 sectors are available (FEFh expressed in decimal).

The modified VDISK program checks the number of sectors implied by the choice of n__k and s__size. If the result exceeds 4,079, a warning message is displayed. The resulting file should not be used. Table 2 illustrates the trade-offs for some typical VDISK configurations. In all cases the directories had 32 entries and the disk had one FAT. The files used to test the disks were copied directly from the DOS 2.0 distribution disks. The 64KB VDISK used different files because of its size.

As expected, all of the disks with 512-byte sectors have more initial space available because their FATs are smaller in size. When data are copied onto the disks, the 128-byte sectors show their worth by wasting less space at the end of each file. As a result, 128-byte sectors are more practical, particularly for smaller VDISK sizes.

The BASIC program in listing 2 will compute the space information needed to compare VDISK configurations. The input values are the total VDISK size in kilobytes and the sector size in bytes. The output includes all the values that have been discussed so far.

If the actual amount of wasted space for each of the files is calculated, the average is closer to one-quarter of a sector, rather than the half discussed above. This is due to a peculiarity of the file sizes on the DOS diskettes: most of the lengths are multiples of 128 bytes. Since this violates the initial assumption of randomly distributed file lengths, it is not surprising that the results are not quite what was expected.

The concept of *allocation units*, or clusters, deserves one more mention, for this is the trick DOS uses to manage the sectors on a fixed disk that has more than 4,079 sectors. For example, a 10MB fixed disk has 19,520 sectors. To make them all fit into a standard FAT, eight sectors are grouped into each cluster, reducing the number of entries to 2,440. The FAT entries point to the first sector of a cluster, with the other sectors following in sequential order.

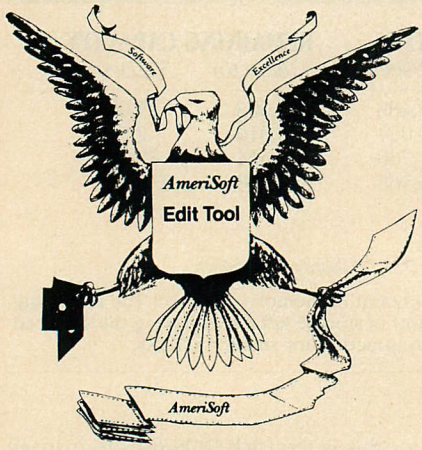
One consequence of clustering is that the minimum file size is the same as the cluster size: the smallest file on a fixed disk is 4KB (8 sectors of 512 bytes each). Therefore, putting more than one sector per cluster on a VDISK works against the value of smaller sectors by increasing the wasted space at the end of each cluster.

Examples of customized VDISKs are described below. The exact trade-offs are unique to these specific applications, but similar reasoning can be used in the design of any set of VDISKs.

The system used has 576KB of RAM (two 256KB multifunction boards plus the 64KB on the system board). Since it has the "old" PC ROMs, only 544KB is selectable using the DIP switches on the system board. A simple printer spooler was written that uses the last 32KB as a buffer, so it does not go to waste. The 544KB usable by DOS is generally divided into three areas: two VDISKs and the RAM available for programs.

The number of VDISK variables for these applications can be reduced to just one: the size of the VDISK. All of the VDISKs used here have 128-byte sectors, one FAT, and a directory that can contain as many as 32 files. While this may not be optimum for each application, it is fairly close and helps keep confusion to a minimum.

To help in remembering which VDISK is which, a simple naming system can be used: in this case, all VDISK files can be named VDISKxxx.SYS, where xxx is the VDISK size in kilobytes (a 220KB VDISK would be named



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VDISK220.SYS). This creation of a "library" of VDISKs is good to have on hand. Even if more than one variable is changed, a simple, systematic structure for designating the disk's configuration usually works best.

If the following two lines

```
device = vdisk220.sys
device = vdisk170.sys
```

are placed in the CONFIG.SYS file, two VDISKs will be allocated: one with drive C: that has 220KB and a second with drive D: that has 170KB. The number of VDISKs will be limited practically by the amount of system RAM.

For a specific example, this article was written with a text-editing system composed of WordVision and Word Proof. Since the information on the VDISK would be lost if the power failed, the text files were kept on a real floppy in drive A:. Drive C: was a 180KB VDISK containing all of the program files for WordVision and Word Proof, along with a few batch files and system utilities. Drive D: was another 180KB VDISK containing the word lists for Word Proof and the DOS-compatible output from WordVision, which was used as input to Word Proof.

The C: drive has about 34KB to spare; the D: drive has about 32KB left. With two 180KB VDISKs, the system RAM is reduced to about 176KB, which allows WordVision enough headroom to edit a rather large file. (The file for this article occupies about 50 percent of the available RAM in WordVision; when saved as a standard DOS file on D: for Word Proof, it is about 25KB long.)

For creating assembly language programs, the system is set up with two VDISKs: C: is 220KB and D: is 170KB. C: contains the Macro Assembler, Linker, Personal Editor, and numerous utilities and batch files. D: contains the source, object, and listing files for the program being written. While this seems to violate the rule of not using a VDISK for source files, by editing the source on the A: drive and saving a copy to D: before doing the assembly, the "real" source is on a "real" floppy while the assembly is done entirely on VDISKs.

A 200/180KB VDISK system serves well for general use. The 200KB VDISK on C: contains the normal DOS files, the Personal Editor, and a few miscellaneous programs. Several other disks assume that the C: drive is already set up and copy special-purpose programs and data onto the D: drive.

Not all systems benefit from the use of two VDISKs. IBM's APL, for example, requires a great deal of free RAM for its "elastic workspace," so the APL

FIGURE 1: *Batch Files to Initialize a VDISK*

AUTOEXEC.BAT WILL CONTAIN

```
copy cauto.bat c:          put the "real" batch file on C:
c:                         make C: the default drive
cauto                      pass control to CAUTO.BAT
```

CAUTO.BAT WILL CONTAIN

```
copy a:otherone.com        get screen-switch utility
otherone                   initialize color monitor
otherone                   return display to monochrome
copy a:xtime.com           get clock-calendar utility
xtime                      set the date and time
erase xtime.com            dispose of utility
copy a:monosave.com        get monitor blanker utility
monosave 180 /normal       set blanking interval
path c:\;d:\;a:\           establish command search order
copy a:command.com         get a copy
copy a:comzap.com          get comspec bug fixer utility
set comspec=c:\command.com tell DOS where COMMAND.COM is
comzap                     patch around DOS bug
erase comzap.com           dispose of utility
cls                        get rid of messages so far
prompt $p $g               set prompt to show subdirectory
verify on                  check every disk write
copy a:printint.com        get my printer spooler
printint                   install it
copy a:pe.*                  following are all the files
copy a:chkdsk.com            normally found in the A: drive
copy a:basica.com            which you'll need on the VDISK
  .
  .                          (whatever you want!)
  .
cls                        get rid of more messages
erase c:cauto.bat          dispose of this file!
```

Because of the way in which DOS executes batch files, erasing CAUTO.BAT from within itself will cause an error message. In order to avoid the message, manually insert an EOF character (Ctr1-Z) as the last character in the last line. This procedure will result in two EOFs in a row (the second one being the "real" one), but the first one will prevent DOS from trying to re-open the file after the last line.

Assume that the VDISK is C: and will be used to contain DOS system files. The comments will indicate what function the commands perform. Remember, however, that the comments do not actually show up in the batch file.

interpreter, a few auxiliary processors, and some DOS utilities are placed on one large VDISK. The rest of RAM is thus available for APL's use and the A: drive is free for data files.

One frustration with VDISKs is the initial effort necessary to load files onto them. First, to minimize head diskette motion, the files should be arranged on the disk in the order DOS will look for them during the boot sequence. On a system disk, this order means that the first three files must be IBMBIO.COM, IBMDOS.COM, and COMMAND.COM. Following that should be CONFIG.SYS, ANSI.SYS (if used), and then the VDISKxxx.SYS files. Following that is AUTOEXEC.BAT and all the files to be copied onto the VDISKs.

In addition to being sequential, all the files should be written to the disk on contiguous sectors. The simplest way to prevent noncontiguous sectors is always to start with a freshly formatted system diskette and copy the files onto it in the desired order.

If the AUTOEXEC file copies a second batch file to the VDISK and then transfers control to it, the remaining copies will be much quieter and faster. If both the batch file and the data files are on the floppy, DOS must read one line from the batch file between each data-file transfer, causing considerable disk grinding. The batch files in figure 1 illustrate the process. It is generally faster to copy single-use programs, such as those that set the date and time and initialize peripherals, onto the VDISK, execute them, and then erase them, than it is to execute them from the A: disk.

Although RAMdisk software is often included "free" with various hardware products, the working environment often has been fixed by the manufacturer. An understanding of the VDISK device driver optimizes the user's ability to put system memory to work for specific situations, and it, too, is "free."

Ed Nisley is a staff engineer for IBM in advanced graphics development.

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LISTING 1: MODS.ASM

```
Note:  Line numbers refer to the listing in the DOS 2.0
manual, pages 14-27 through 14-34.


<<change 0:  delete lines 3 through 7 >>
<<change 1:  insert before line 8 >>
        page    ,132
;---------------------------------------------------------------
; This is an installable device driver to emulate a diskette
; drive.    It is altered slightly from the code in the DOS
; 2.00 manual (page 14-27..34)   to simplify changing the
; disk emulation variables.  The ES:BX bug at the device
; interrupt entry point is fixed.
; Guidelines for choosing the parameters:
;
; The number of bytes reserved for the disk must be a whole number:
; for example, you cannot reserve 180.5 K.
; 1 K-byte equals 1024 bytes.
;
; The sector size should be 128, 256 or 512 bytes.
; Smaller sectors waste too much space by having a large FAT.
; Larger sectors waste too much space at the end of each file.
; The largest sector possible with this code is 1024 bytes
; due to truncation in the n_sects equation
; The sector size must always be a power of 2.
;
; The number of directory entries should be kept small.
; About 32 entries is appropriate for most uses of a VDISK.
; Each directory entry requires 32 bytes.
;
; Choose the number of directory entries to completely fill
; the directory   sectors, which will avoid wasting space.
; The number of FATs should be set to 1.  Real disks have
; duplicated FATs   to increase reliability, but that's not a
; problem with VDISKs.
;--------------
; modifications by Ed Nisley  23 April 84  Compuserve 74065,1363
;--------------

        page
```

```
;--------------
; Change the following four variables to configure the VDISK

n_k     equ     180     ; k-bytes reserved for disk storage
s_size  equ     128     ; bytes per sector
n_files equ     32      ; maximum number of files on the VDISK
n_fats  equ     1       ; number of FATs used:only 1 or 2 allowed



; Do not change any other values
;--------------
;--------------
; The parentheses in the expressions for n_sects and n_para
; are required   to prevent numeric overflow.  Do not omit them!

n_sects equ     n_k*(1024/s_size)     ; number of disk sectors

        if      n_sects GT 4079     ; check for FAT overflow
        %out    WARNING!  TOO MANY SECTORS!
        %out    Increase s_size or decrease n_k
        %out    WARNING!  OUTPUT FILE IS INVALID!
        endif

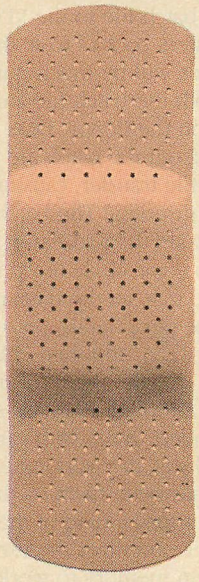
n_para  equ     n_k*(1024/16)           ; no.of disk paragraphs

fat_b   equ     3*n_sects/2             ; no. of bytes in each FAT
fat_s   =       fat_b/s_size            ; no of sectors per FAT
        if      fat_b NE (fat_s*s_size) ; check for truncation
fat_s   =       fat_s+1                 ; if so, round to
        endif                           ; next whole sector


dir_b   equ     n_files*32              ; no. of bytes in directory
dir_s   =       dir_b/s_size            ; no. of directory sectors
        if      dir_b NE (dir_s*s_size) ; check for truncation
dir_s   =       dir_s+1                 ; if so, round to next
        endif                           ; whole sector
dir_at  equ     1+(n_fats*fat_s)        ; starting sector for
                                        ; directory


        page
;--------------
```


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```
; Begin the code segment
<< change 2:  replace line 87 >>          ; sector size
        dw      s_size
<< change 3:  replace line 90 >>          ; number of FATs
        db      n_fats
<< change 4:  replace line 91 >>          ; number of directory
        dw      n_files                   ; entries
<< change 5:  replace line 92 >>          ; total number of
        dw      n_sects                   ; sectors
<< change 6:  replace line 94 >>          ; number of sectors in FAT
        dw      fat_s
<< change 7:  replace line 110 >>         ; number of bytes/sector
        dw      s_size
<< change 8:  replace line 113 >>         ; FATs
        db      n_fats
<< change 9:  replace line 114 >>         ; directory entries
        dw      n_files
<< change 10:  replace line 115 >>        ; total number of sectors
        dw      n_sects
<< change 11:  replace line 117 >>        ; sectors in FAT
        dw      fat_s
<< change 12:  replace line 151 >>        ; multiply by # paras in
        mov     cx,s_size/16              ; sector
<< change 13:  replace line 158 >>        ;  ... times bytes/sector
        mov     cx,s_size
        mov     cx,s_size                 ;  ... times bytes/sector
<< change 14:  insert after line 227 >>   ; set up request
        mov     bx,cs:rh_off              ; header pointer
        mov     es,cs:rh_seg
<< change 15:  replace line 248 >>        ; add in enough room
        mov     ax,n_para                 ; for the disk
<< change 16:  replace line 262 >>        ; and number of sectors
        mov     cs:word ptr total,fat_s
<< change 17:  insert after line 271 >>   ; if using two FATs...
        IF      n_fats NE 1
<< change 18:  replace line 274 >>        ; 2nd FAT start sector
        mov     cs:word ptr start_sec,1+fat_s
<< change 19:  replace line 275 >>        ; and number of sectors
        mov     cs:word ptr total,fat_s
<< change 20:  insert after line 282 >>
        ENDIF
<< change 21:  replace line 283 >>        ; starting sector num
        mov     cs:word ptr start_sec,dir_at
<< change 22:  replace line 284 >>        ; and number of sects
        mov     cs:word ptr total,dir_s
<< change 23:  insert after 344 >>        ; divert "impossible"
        jmp     exit                      ; calls safely
```

LISTING 2: CALC.BAS

```
1  ' VDISK calculator
2  ' Ed Nisley   23 April 84
3  '
10 KEY OFF
20 NFILES=32              ' number of file entries in directory
30 NFATS=1                ' number of fats used
40 NRES=1                 ' number of reserved sectors
50 CLS                    ' this is the top of the calculator loop
60 INPUT "Total disk capacity (kbytes): ",KBYTES
70 INPUT "Number of bytes per sector: ",SSIZE
80 PRINT "Assumed:"
90 PRINT "  Dir entries:";TAB(22);NFILES
100 PRINT "  FATs used:";TAB(22);NFATS
110 PRINT "  Reserved sectors:";TAB(22);NRES
120 NSECTS=KBYTES*1024/SSIZE              ' total sectors
130 IF NSECTS>4079 THEN
    TOOBIG$=" << Too many sectors for FAT" ELSE TOOBIG$=""
140 FATSECTS=-INT(-1.5*NSECTS/SSIZE)      ' sectors in one FAT
150 DIRSECTS=-INT(-NFILES*32/SSIZE)       ' sectors in directory
160 PRINT "Calculated:"
170 PRINT "  Total sectors:";TAB(22);NSECTS;TOOBIG$
180 PRINT "  FAT sectors:";TAB(22);NFATS*FATSECTS
190 PRINT "  Dir sectors";TAB(22);DIRSECTS
200 NETSECTS=NSECTS-NFATS*FATSECTS-DIRSECTS-NRES
210 PRINT "  Available sectors:";TAB(22);NETSECTS
220 NET=NETSECTS*SSIZE
230 PRINT "  Bytes available:";TAB(22);NET
240 LOSS=KBYTES*1024-NET
250 PRINT "  Loss (bytes):";TAB(22);LOSS
260 PCT=.01*CINT(10000*LOSS/(KBYTES*1024))
270 PRINT "  Loss (percent):";TAB(22);PCT
280 PRINT ""
290 INPUT "Press return to continue...",TRASH$
300 GOTO 50
```


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#Open files	255	2	10
#Fields	Unlimited	32	128
Record size	Unlimited	1024	4096
Multi key ISAM	Yes	Needs sorting	Needs sorting
LOCAL AREA NETWORKS			
File lock	Yes	No	No
Record lock	Yes	No	No
PORTABILITY			
8-bit → 16-bit	Yes	Yes	No
16-bit → 8-bit	Yes	Yes	No
MISCELLANEOUS			
Formatted data entry	Full	Limited	Limited
Report generator	Full	Limited	Limited
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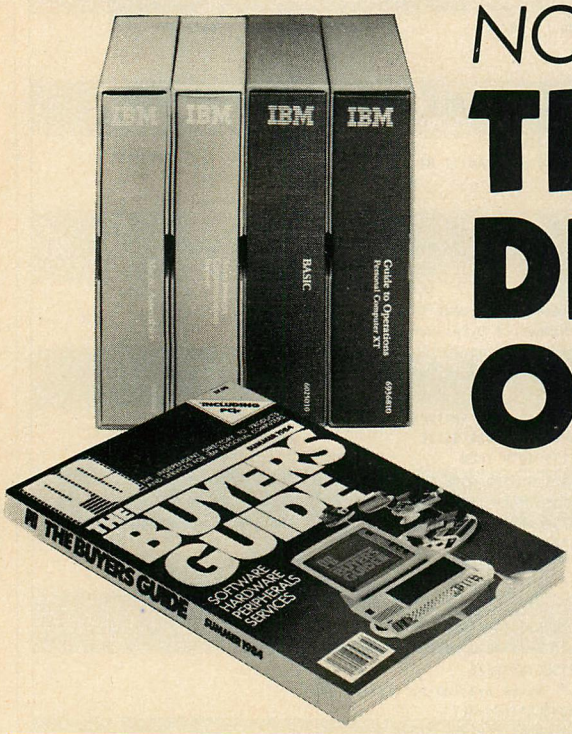
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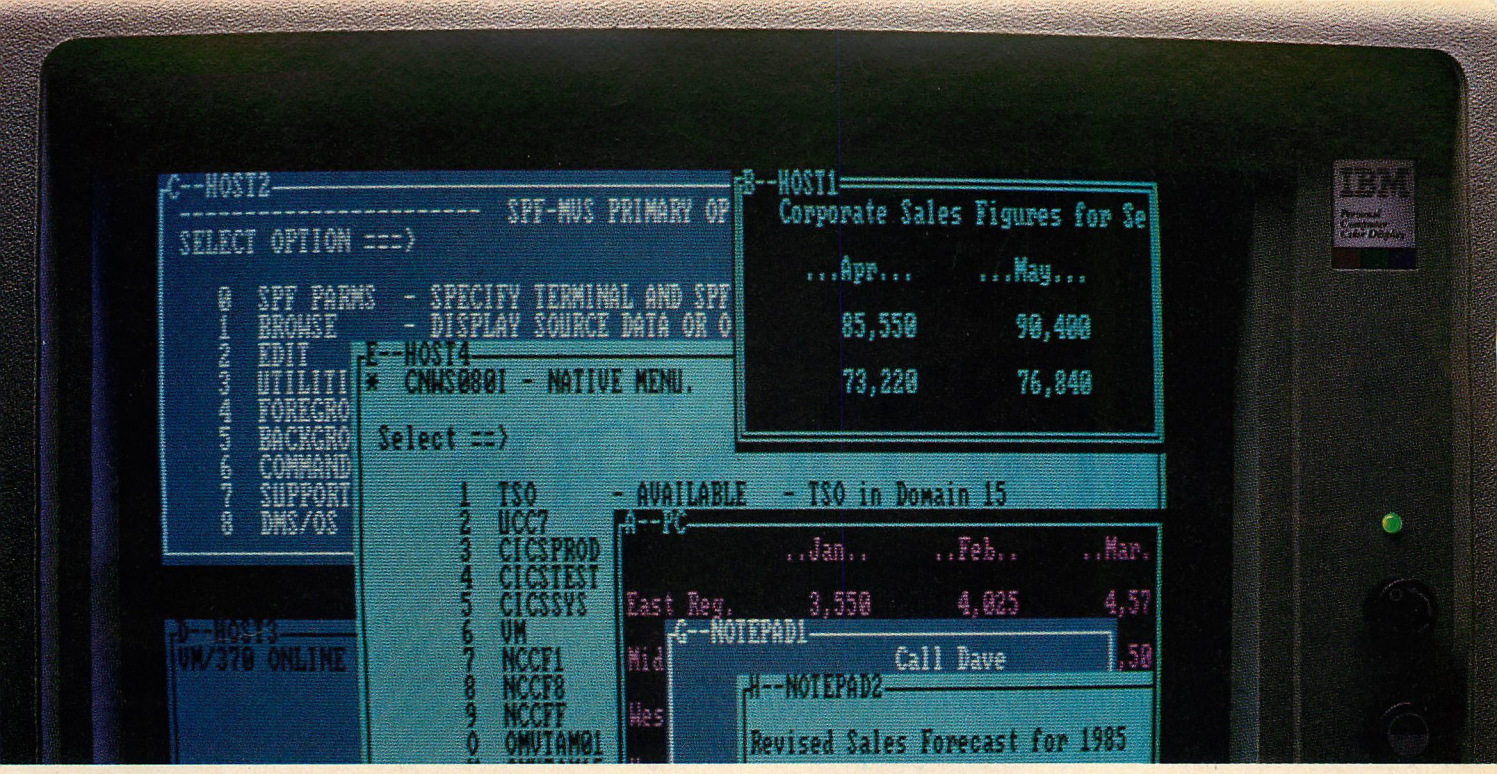
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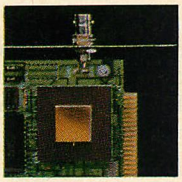
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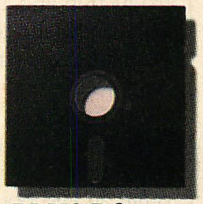


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In the search for the perfect electrical circuit, you are well-equipped with Micro-Logic, a high-powered logic design and simulation system by Spectrum Software.

WILLIAM H. MURRAY

Spectrum Software has published two software programs to help design and simulate actual electrical circuits. Micro-Cap, which received high marks in my review in the March 1984 issue of *PC Tech Journal*, is an analog circuit designer. Micro-Logic, a digital circuit designer, is equally impressive. It is flexible and easy to use, with a well-written manual. Micro-Logic allows digital circuits to be designed on the graphics screen of the IBM PC and XT. The created circuits "draw" their symbols from an internal library of logic gates. Once created, the "drawn" logic circuits can be made to act like real logic gates that are wired together; a timing diagram that simulates the actual functioning of the circuit can be created.

Micro-Logic comes in a three-ring indexed binder. The actual program resides on one of the three single-sided diskettes included with the binder. The remaining two diskettes are a data diskette for storing circuit creations and an enthralling self-running demo program. The data diskette also contains library files that are necessary for the proper execution of the program.

At least one back-up copy of the disks *must* be made. I made several "wrong turns" while doing this review and would have lost everything had it not been for my back-up copies.

Micro-Logic requires an IBM PC or XT with a minimum of 192KB of RAM, two disk drives (single- or double-sided), DOS 1.1 or 2.0, a color graphics board and color (or green screen) monitor, and an optional printer (IBM or Epson MX-80 suggested). If software is available to do a screen dump with a Shift-PrtSc, using another brand of printer should be no problem.

Micro-Logic's manual is divided into seven sections; in addition to an introduction and appendixes, these sections cover the designer module, analyzer module, pattern editor, component editor, and simulation module.

Instructions for creating and running a simple digital logic circuit are presented early in the introduction. It is quite an ego boost to see something that appears so complicated turn out to be so easy to use. The number of commands may be imposing at first, but familiarity with Micro-Logic quickly makes them easy to remember.

Running the program is simply a matter of putting a *copy* of the main program in drive A: and a *copy* of the data disk in drive B: and then typing INTRO. The main menu will appear, presenting four choices:

1. The Designer Module
2. The Analyzer Module
3. Make a New Data Diskette
4. End

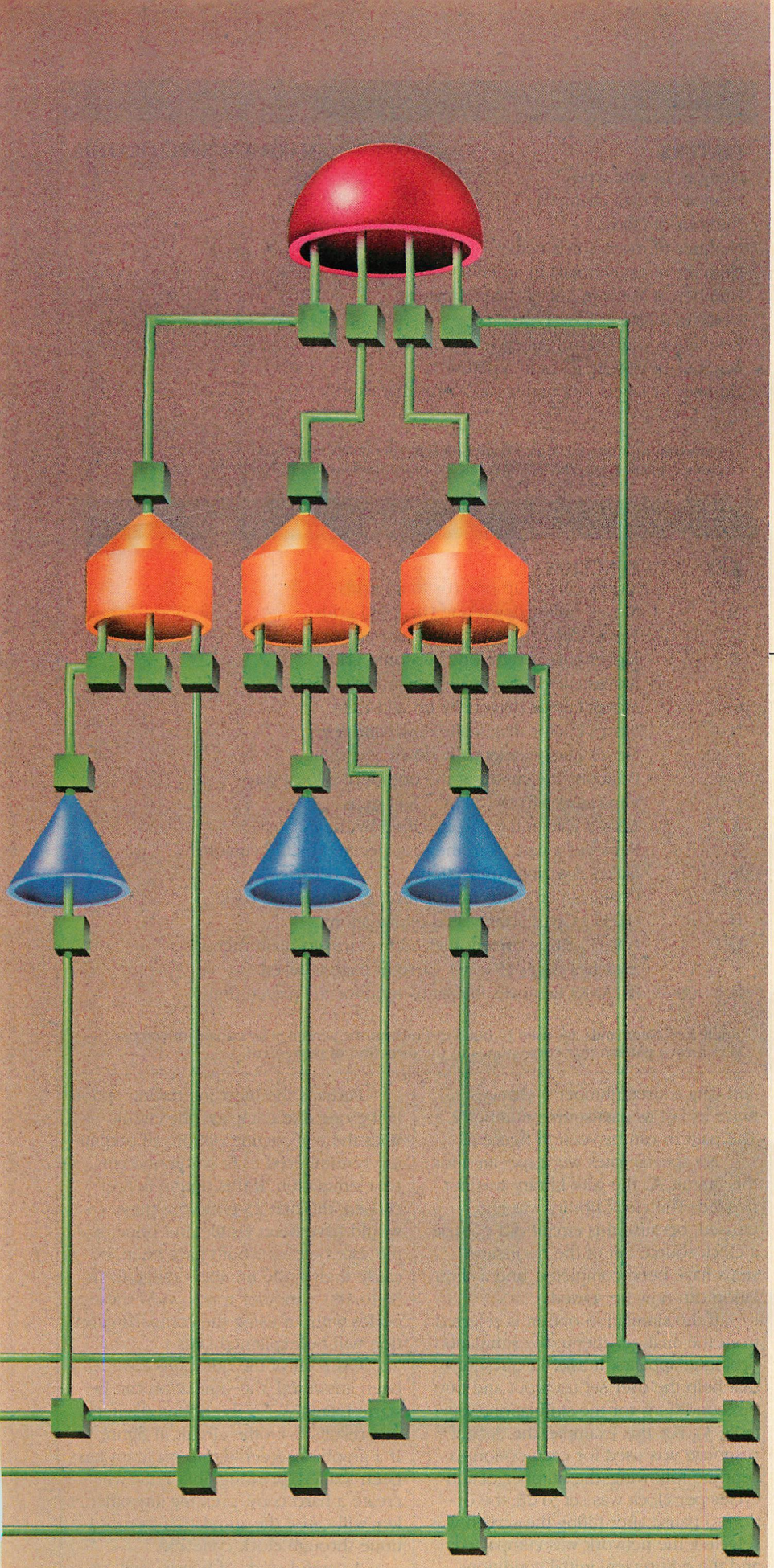
It isn't difficult to figure out that all of the action takes place within the designer and analyzer modules. The designer module can be thought of as the place where digital circuits are "drawn;" the analyzer module is the place where circuits are "run."

Table 1 gives the upper limits for design specifications for Micro-Logic on the IBM PC or XT. Keep in mind that 1,750 gates in a circuit is a fairly large number. When the designer module is used, circuits are drawn on a screen. Currently, the designer module allows nine separate screens, which Spectrum Software calls *pages*. A complete circuit is formed by placing the pages in the following pattern:

0 1 2
3 4 5
6 7 8

Normally, only one page is used at a time, but if the circuit is large, it is possible to switch to the next page. Wires and connections easily can be made to pass from page to page. A page has enough room for 195 gates, arranged in 15 rows of 13 gate sites. These potential sites are numbered from left to right and top to bottom so that row one holds gate sites 1 through 13, row two holds gate sites 14 through 26, etc.

Assume, for example, that page 0 is chosen for use. When that page is entered for the first time, it will be blank except for the status monitor at the top of the screen. The status monitor reports the current status of seven items: the page number; the gate number (the local site nearest the cursor); the node



number (the grid point under the cursor); the node number of the pen when in the "draw" mode; the pen status (up, plot, or erase); cursor step size (x1 or x4); and the next command request.

Table 2 is a list of the single key commands that permit circuits to be created on the screen. Figure 1 shows a simple circuit created using these commands. This circuit illustrates the shape of the most common gates in the gate library and how data are actually entered from the diagram. The small boxes at gates 2, 4, and 6 represent data sources. These are specified by typing A (for add a gate) and responding with DATA 1 for data channel number 1, DATA 2 for data channel 2, etc.

With the exception of the various clock configurations available with Micro-Logic, all data are entered through data channels (even if that data never change—that is, remain logic 1 or logic 0 for the entire simulation). The data for each channel can be chosen when the analyzer module is run.

After the data sources are chosen, the gates are specified. Micro-Logic allows for up to 36 unique gates. Many custom gates can be specified by the user. For the common logic gates, Micro-Logic provides preformed AND, NAND, OR, and NOR gates of three and five inputs. EXCLUSIVE OR gates have two inputs and INVERTERS, naturally, have one input. A four-input AND gate can be made from a five-input AND gate

ILLUSTRATOR • JOE SCROFANI

or created with the gate editor contained in the analyzer module.

The wiring is done next by connecting gate outputs to gate inputs. A (C)onnection is made by placing the cursor at the output of DATA 1 and typing C. A wire can be drawn across the screen by using the cursor-movement keys shown in table 2. Although the IBM keyboard cursor keys are not used, the keys chosen by Spectrum Software form a pattern on the keyboard that corresponds to the desired direction of cursor movement. When the wire reaches its final destination, it is connected by typing C once again.

Notice the small square boxes on the wires in figure 1. They indicate that a connection has been made. Wires crossing one another do not "connect" unless specifically told to do so with the (C)onnect command.

Of the 18 predefined gates, only eight were used in this example. A maximum of 36 gate types can be defined with Micro-Logic. They are: INV, NOR3, NOR5, NAND3, NAND5, EX-OR, OR3, OR5, AND3, AND5, DFFTTL, TFFTTL, JKTTL, BUFFER, T GATE, DFFMOS, TFFMOS, and a JKMOS.

Once the circuit is finished, typing Q (for Quit) saves it on drive B: and returns to the main menu.

After a circuit has been created with the designer module, the next step is to prepare to simulate actual circuit operations. Selecting the analyzer module from the main menu produces the analyzer menu. This menu presents eight options: Network Editor, Disk Operations, Start a Simulation, Utilities, Test Pattern Editor, Gate Library, Clock Library, and Return to Main Menu.

Several initial conditions must be set up before a simulation of the circuit in figure 1 can be started. First, figure 1's circuit, which was saved to the disk earlier, must be retrieved. This is done by selecting the disk operations option and pressing Return when asked for the circuit. Micro-Logic will automatically select the last designer-module circuit and load that into memory.

For the circuit in figure 1, the test-pattern editor must also be used to establish the binary patterns for the three data sources. The test-pattern editor permits several pattern options. The wave patterns can remain logic 1 or logic 0 for the entire simulation, or they can produce any variety of logic 1 and logic 0 shifts with each clock pulse. In this particular example, data source number 1 changes from logic 1 to logic 0 once during the initial eight clock pulses. Data source number 2 changes twice as fast as data source number 1, and data source number 3 changes twice as fast as data source number 2. The pattern can be seen in figure 2.

TABLE 1: *Maximum Specifications for Micro-Logic*

FEATURE	MAXIMUM SPECIFICATION
Number of gate types	36
Number of data channels	36
Number of clocks	9
Number of macros in a netlist	50
Number of gates (total) in a netlist	1,750
Number of states in a data-channel pattern	256
Delay of a gate	13
Resolution (number of subcycles per clock)	100
Number of tri-state gates in a netlist	200
Number of labels in a netlist (up to six characters)	200

The maximum limits for Micro-Logic's design specifications should be sufficient for most circuits; 36 gate types and 1,750 gates are more than would normally be required.

TABLE 2: *Designer-module Cursor Commands*

KEY	FUNCTION
I	Moves cursor up one (or four) grids
M	Moves cursor down one (or four) grids
J	Moves cursor left one (or four) grids
K	Moves cursor right one (or four) grids
U	Moves cursor diagonally up and left
O	Moves cursor diagonally up and right
N	Moves cursor diagonally down and left
,	Moves cursor diagonally down and right
L	Positions the cursor at the output of a local gate
F	Flips cursor from (X1) to (X4) steps
A	Adds a gate at the site specified by the cursor
R	Removes a gate from the site specified by the cursor
C	Makes a wiring connection
P	Changes pen status from DRAW to ERASE and back
H	(HELP) Gives abbreviated explanations
Q	(QUIT) Saves current files and returns to main menu
S	Switches pages (0 to 8). Current page is saved
B	(BLANK) Removes the status monitor for screen dumps

Single key commands are used to build circuits on the screen. The cursor movement keys form a pattern that corresponds to the direction of movement.

No special gates were specified for this circuit, so the gate library was not needed. The clock library was also unused, because this circuit did not use a clock source. All of the necessary steps have been completed, and a simulation can now be started.

If the simulation option is selected from the analyzer menu, the simulation prologue appears. It asks 12 questions that help the user set up input and output conditions for the simulation (see table 3). For this example, the default response was used for each option except the following: the number of subcycles per clock was set to 25; the option to pause after filling the screen was selected; the network was compacted; and the edit/review initial conditions feature was chosen.

Perhaps the most interesting option is the one that compacts the circuit. With the compacting option, all outputs are renumbered to fit within the current simulation. If this option is not chosen, the first 23 node positions would have been visible, but none of the gate outputs would have been, because their node numbers range from 36 to 180. (Another way to view these nodes without using the compacting option will be explained later.)

Once all of the questions have been answered, the simulation can be started. Figure 2 is the timing diagram that results from the circuit in figure 1. If a graphics screen-dump program has been loaded, pressing Shift-PrtSc will create a hard copy; pressing any other key will cause the simulation to continue through clock cycle 256.

A careful study of figure 2 will reveal the truth-table definitions for each

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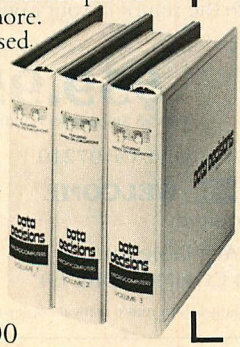
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of the various gates. For example, look at node 4, which defines an AND gate. The output of the AND gate will be logic 1 only when all of its inputs are logic 1. Did it work? Yes, indeed!

Of course, creating this circuit was not a high-powered design project that took advantage of a lot of user's options, but it was intended only as a warm-up exercise. Now that the fundamentals of entering and simulating circuits have been explained, a more interesting example can be presented.

Micro-Logic contains a useful simulation feature that permits the user to select variable gate delays. These propagation delays, simply put, represent the time it takes a gate to process the input information and produce an output. Figure 3, a simple, 6-bit JK asynchronous up counter that was drawn with the designer module, illustrates this simulation feature. The JK inputs of each flip-flop will be held at logic 1 for the entire simulation. The outputs of each JK will then be observed on the simulated timing diagrams of figures 4 and 5.

Note that the compacting option was not used in figures 4 and 5. Instead, the choice of which nodes would be viewed was determined by selecting the utilities option in the analyzer menu. Figures 4 and 5 show the correct node numbers instead of the renumbered nodes that occurred in figure 2.

Option number 9 from the simulation prologue permits variations in the gate delays. Figure 4 uses a (F)ixed delay. The fixed delay option sets the gate-delay value to one that was defined with that particular gate. For this JK flip-flop, the fixed gate value is one unit (all times are relative to the simulation time units). Figure 5, on the other hand, uses a (C)alculated delay, based on the equation $T = F + (V * N)$ where T = total delay, F = fixed-delay value, V = variable delay (initially 1 for this gate), and N = Fan-out.

Comparing clock cycle number 65 in figure 5 with the same cycle of figure 4 will show how that pattern changes for an increased delay. The number of potential problems this feature might uncover for a circuit is enormous.

LOADED FOR BEAR

"Loaded for bear" is a phrase used by hunters when they are armed with high-powered equipment. To illustrate how Micro-Logic takes the user into the hunt "loaded for bear," the next example tackles an imaginary design problem from start to finish and then implements the circuit with Micro-Logic to discover any mistakes in the original design or in the actual circuit operation.

TABLE 3: *The Simulation Prologue from the Analyzer Module*

SAVE (S) RECALL (R) OR NEW SIMULATION (N) (S,R,N DEFAULT = N) ?
(N), the default, is the normal simulation mode. If (S) is selected, the timing diagrams are saved for later playback. (R) recalls the previously saved diagrams for replay.

ENTER FINAL CLOCK CYCLE TO RUN (DEFAULT = 256) ?
This option allows the user to specify a number of clock cycles, up to 256, to be viewed during a simulation. A technique is provided for higher cycles.

ENTER THE NAME OF THE DATA CHANNEL PATTERN TO USE (DEFAULT = xxx) ?
Normally, the user will choose the default, which is the just-constructed data-channel pattern. However, if a pattern has been previously saved, it can be recalled at this point.

ENTER THE NO. OF SUBCYCLES PER CLOCK (5-100, DEFAULT = 20) ?
This option determines the timing resolution. Each clock cycle can be resolved into 5 to 100 subcycles. The gate delay is specified in terms of subcycles. Varying this option changes the magnification of the timing diagram.

ENTER THE SCALE FACTOR FOR TIME BASE (1,2,4,6,8 DEFAULT = 2) ?
The scale factor represents the number of high-resolution points separating each unit of subcycle time. A value of 1, for example, will permit 26 clock cycles to be displayed at one time.

PLOT SUBCYCLE GRIDS (Y/N DEFAULT = N) ?
Draws a vertical line on the timing diagram on each side of a subcycle. This is excellent for resolving timing differences, but produces a crowded screen dump.

PLOT CLOCK GRIDS (Y/N DEFAULT = N) ?
This option will plot a vertical line at the beginning of each clock cycle.

PAUSE EACH SCREEN (Y/N DEFAULT = N) ?
This option causes the system to pause after completing each page. The user then is able to study each page in detail and produce a screen dump if desired, before continuing on to the next page.

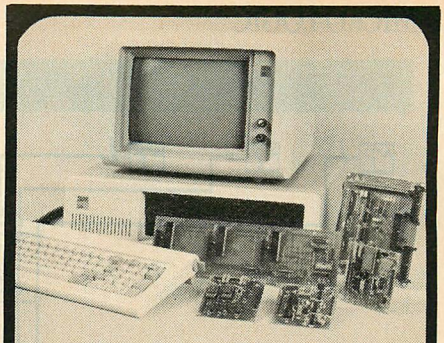
USE CALCULATED (C), FIXED (F), PRIOR (P) OR UNIT (U) GATE DELAYS (DEFAULT = F) ?
Each gate in Micro-Logic has a propagation delay value in the specifications for the gate. These values can range from 1 to 13 units of subcycle time. They can also be redefined by using the gate editor. For the JK flip-flop, the Fixed (F) delay and variable delay are 1 unit. If the Prior (P) option is selected, the delay value previously used will be used again. If the Calculated (C) option is selected, then a new value will be calculated based on the Fixed (F) and variable delays and the fan-out in the circuit.

SAVE RESULTS TO PRINTER (P), DISK (D) OR NEITHER (N) (P,D,N DEFAULT = N) ?
This option allows the user to save the states of the selected nodes to the printer or disk. This can use a large amount of disk space if the circuit is big.

COMPACT THE NETWORK (Y/N DEFAULT = N) ?
Normally, the first 23 gate sites are displayed on the timing diagram. Because many of these may not be used in a diagram, compacting the circuit removes blank gate sites and packs the remaining sites into the 23 displayed lines. This is useful for quick checks, but it is far better to redefine the nodes with the utility option (analyzer menu). Compacting changes the node numbers to form a sequential list that has nothing to do with the original circuit.

EDIT/REVIEW INITIAL CONDITIONS (Y/N DEFAULT = N) ?
This feature allows the user to set the values of the initial states of each gate's output. It is useful for sequential design work involving flip-flops, etc. Gate outputs can be set to logic 1 or logic 0.

The analyzer module prologue asks 12 questions to help the user set up parameters for the simulation. The default response for each question is presented in parentheses.



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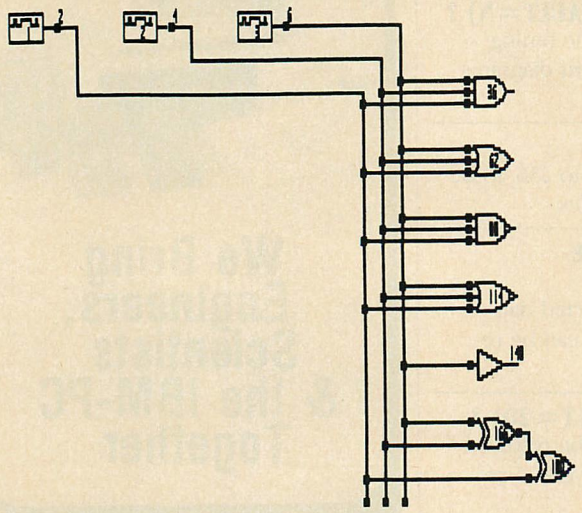
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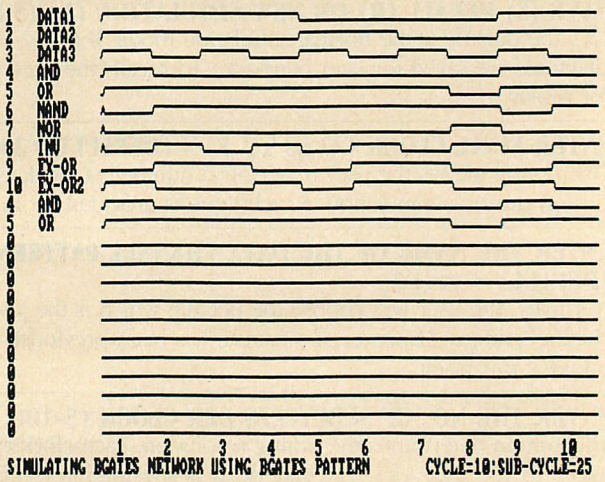
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FIGURE 1: *Simple Circuit Design*



This circuit, which was created using single-key commands, shows the representation of data sources and the most common gates.

FIGURE 2: *Simple Circuit Analysis*



Binary patterns are represented in this timing diagram for each of the basic logic gates for the circuit shown in figure 1.

In order to accomplish this, a few design aids are necessary to help create the logic circuit.

Late one Friday afternoon (when else!), Frank was given an assignment by his boss, A.K. Krumcake of the Costmore Toy Company. Krumcake, being a kind soul, gave Frank until the following Monday morning to design an LED display for the company's new "Hunt the Bear" game. A circuit had been designed by Fedimore Digitab to produce a binary count, at random, from 0 to 9. Frank's job was to create a decoder circuit that would display this number on a seven-segment display. "Hunt the Bear" was to use Fedimore Digitab's circuit as the binary input source.

Frank produced his most creative effort for a seven-segment display at 6 p.m. that Sunday night. He then needed to produce a truth table (figure 6) to represent when the various light segments would be lit, reduce it (figure 7), and implement the logic diagram on Micro-Logic's designer module.

Fortunately, Frank was an avid reader of *PC Tech Journal* and remembered that a circuit-reduction technique appeared in an article called "Simple Circuits, Better Circuits," in the February 1984 issue (William H. Murray and Chris H. Pappas, page 118). With the optional program, KEYTTL, the reduction process from truth table (figure 6) to Boolean expression (figure 7) took only a matter of seconds. He was then ready to draw the circuit.

With nine designer pages to draw on and a pressing deadline, Frank decided not to try to squeeze the whole circuit onto one page. His luck held again, because Micro-Logic allows each of the pages to be electrically connected. Figures 8, 9, 10, and 11 represent separate pages that make up the single circuit that Frank designed. Gate number 89 represents the *a* segment (the first of the seven segments), number 180 represents the *b* segment, number 284 the *c*, number 375 the *d*, number 479 the *e*, number 570 the *f*, and number 674 the *g*. Figure 8 was drawn on page 0, figure 9 on page 1, figure 10 on page 2, and figure 11 on page 3 of the designer's memory. Notice how electrical connections, from the data sources, are made to each page.

Needless to say, on Monday morning Frank was the hero of the department. Not only had he designed the circuit, but he had also given them a complete analysis in terms of best-case and worst-case conditions. Figure 12, his first simulation, allowed a unit (one) of propagation delay per gate. This was the best-case design. By running the simulation again and taking fan-out into consideration when calculating the propagation delay, he produced figure 13, the worst-case design.

What's more, whereas others might have slaved over prototype boards and oscilloscopes for the entire weekend, Frank accomplished his complete design of the circuit on the porch of his ocean-front condominium.

Micro-Logic truly is "loaded for bear." When used in conjunction with other logic-design tools, such as KEYTTL, Micro-Logic has awesome power. The design and analyzer modules are easy to use. With the various editors provided with the analyzer module, the user can design custom gates, data generators, and clocks.

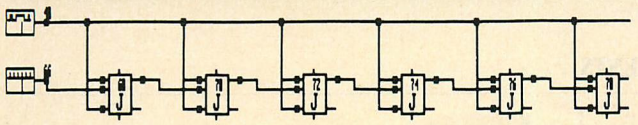
In the simulation mode, it is also easy to control the actual analysis, including expanding and shrinking the time axis and customizing the display format. The upper limits on design size provided with the IBM version should allow for the design of a wide range of circuits. Micro-Logic also contains a macro facility that allows circuits, such as full adders, to be used again and again once they have been designed.

Micro-Logic seems to have only a few minor problems. First, the IBM cursor keys are not used. It is something of a bother to look for the I, J, K, and M keys when the IBM cursor key pad is right there. One other problem is that the manual was written to be common to both the IBM PC/XT and the Apple. For the price, users should not have to sort through text to decide whether a command is meant for the Apple or the IBM. However, these two problems are minor and certainly would not keep me away from this high-quality product.

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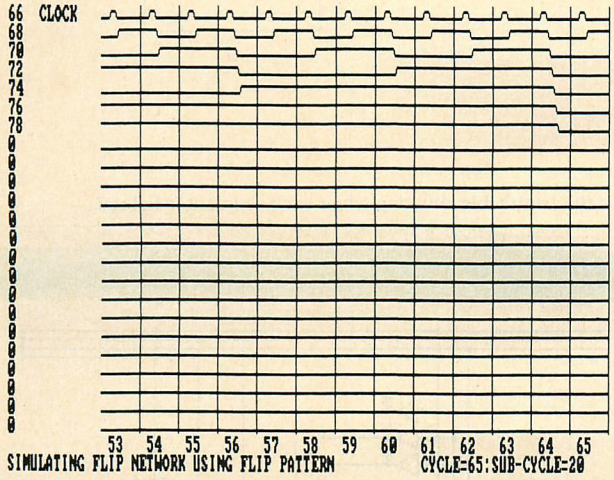
William H. Murray teaches computer science at Broome Community College in Binghamton, NY. With Chris Pappas, he has written An Introduction to APL for the IBM PC and XT, *to be published by Brady Books.*

FIGURE 3: *Up Counter Circuit Design*



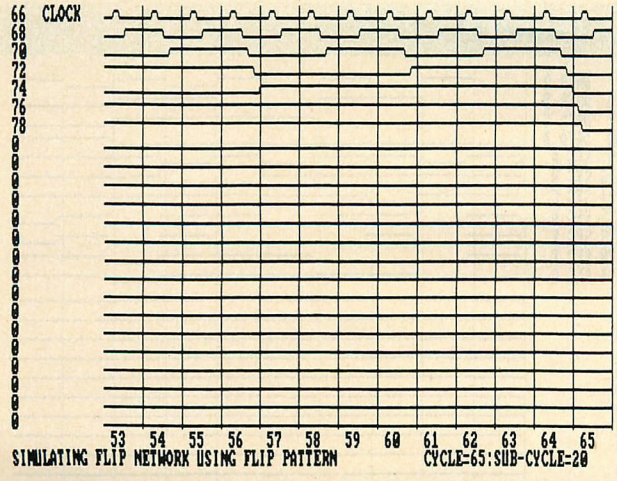
A six-bit, JK asynchronous up counter, drawn with the designer module, is used to illustrate programmable gate delays.

FIGURE 4: *Analysis—Fixed Gate Delay*



This simulated timing diagram shows the outputs of the six JK flip-flops using a fixed gate delay. The fixed gate value is one unit.

FIGURE 5: *Analysis—Calculated Gate Delay*



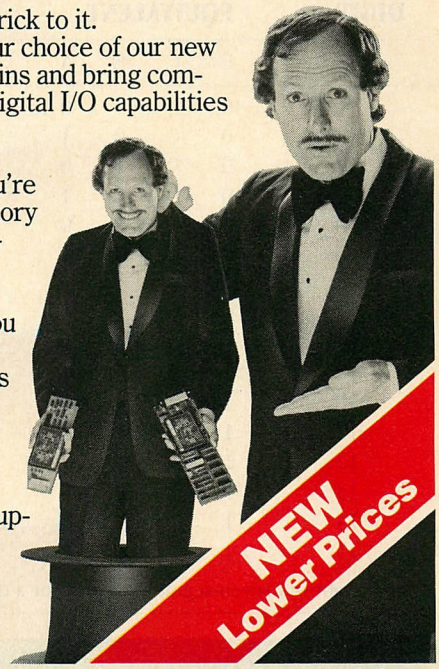
Shown in this simulated timing diagram are the outputs of the six JK flip-flops using a calculated gate delay. Note that the compacting option was used in neither figures 4 nor 5.

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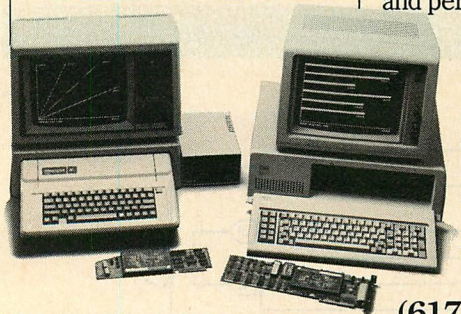
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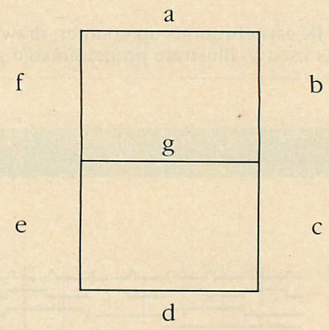
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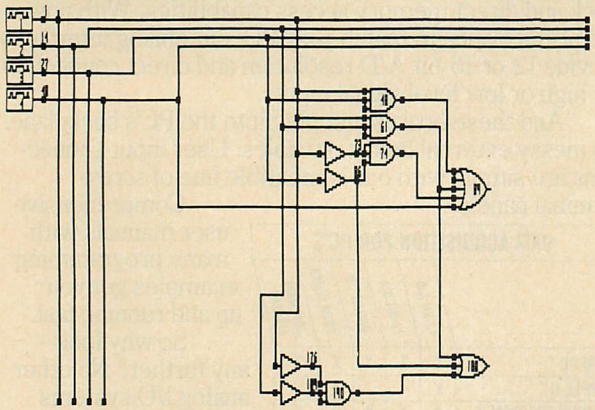
FIGURE 6: *Seven-segment Display Truth Table*

DECIMAL DIGIT	BINARY EQUIVALENT				OUTPUT TO SEGMENTS						
	D	C	B	A	a	b	c	d	e	f	g
0	0	0	0	0	1	1	1	1	1	1	0
1	0	0	0	1	0	1	1	0	0	0	0
2	0	0	1	0	1	1	0	1	1	0	1
3	0	0	1	1	1	1	1	1	0	0	1
4	0	1	0	0	0	1	1	0	0	1	1
5	0	1	0	1	1	0	1	1	0	1	1
6	0	1	1	0	0	0	1	1	1	1	1
7	0	1	1	1	1	1	1	0	0	0	0
8	1	0	0	0	1	1	1	1	1	1	1
9	1	0	0	1	1	1	1	0	0	1	1
10	1	0	1	0				*			
11	1	0	1	1				*			
12	1	1	0	0				Don't Cares			
13	1	1	0	1				*			
14	1	1	1	0				*			
15	1	1	1	1				*			



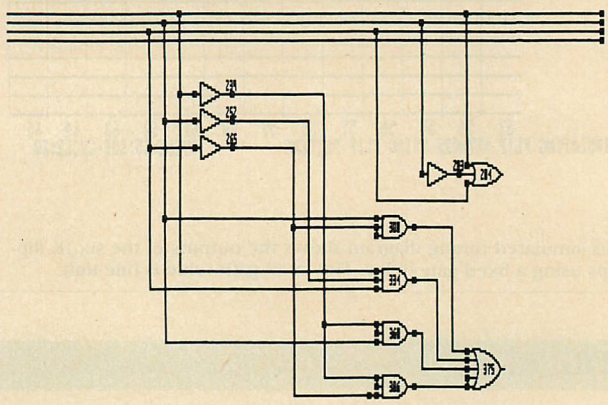
At the right is a seven-segment display for a decoder circuit. To the left is the truth table showing when each segment is lighted.

FIGURE 8: *Page 0 of the Decoder Circuit*



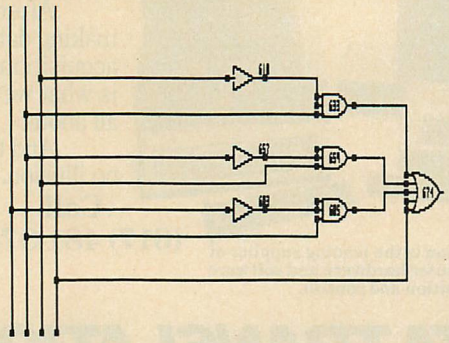
Gate 89 is the output of segment *a*; 180 is the output of segment *b*.

FIGURE 9: *Page 1 of the Decoder Circuit*



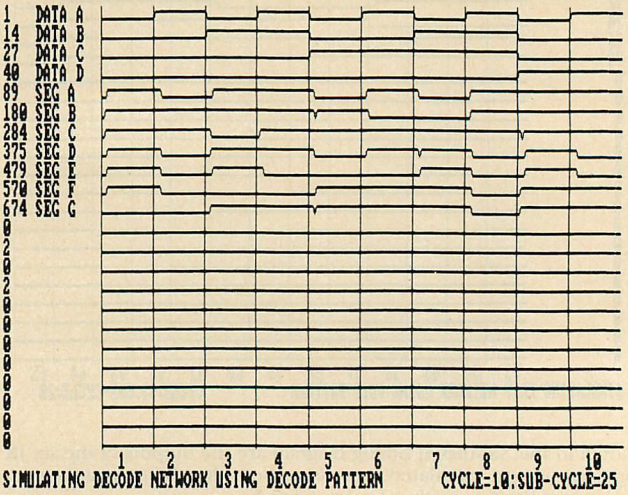
Gate 284 is the output of segment c; 375 is the output of segment d.

FIGURE 11: *Page 3 of the Decoder Circuit*



Gate 675 is the output for segment g. Figures 8-11 combine to form the complete decoder circuit.

FIGURE 12: *Fixed Gate Delay*



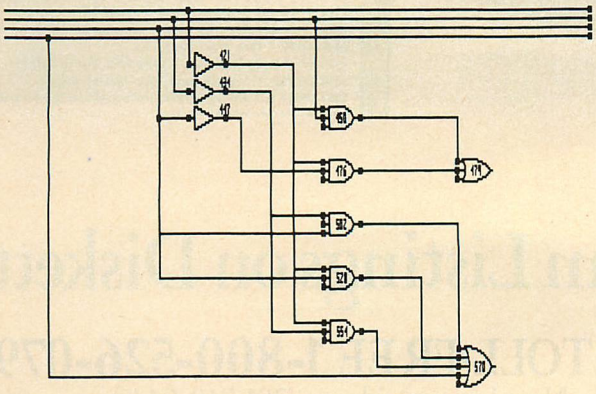
The best-case design allowed one unit of propagation delay per gate.

FIGURE 7: *Reduced Logic*

SEGMENT	REQUIRED LOGIC
a	AB + A'C' + D + AC
b	A'B' + AB + C'
c	C + A + B'
d	BC' + AB'C + A'B + A'C'
e	A'B + A'C'
f	B'C + A'C + A'B' + D
g	BC' + B'C + A'B + D

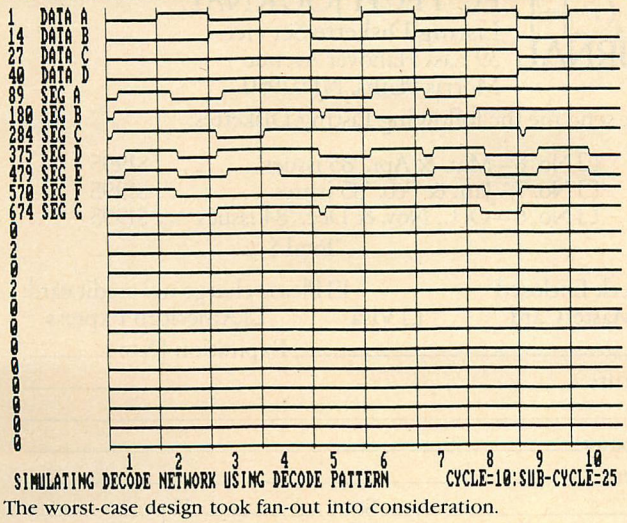
Reduced logic is necessary for each segment of the seven-segment display. Karnaugh Mapping or the Quine-McKluskey Method is used.

FIGURE 10: *Page 2 of the Decoder Circuit*



Gate 479 is the output for segment e; gate 570 is the output for f.

FIGURE 13: *Calculated Gate Delay*



The worst-case design took fan-out into consideration.

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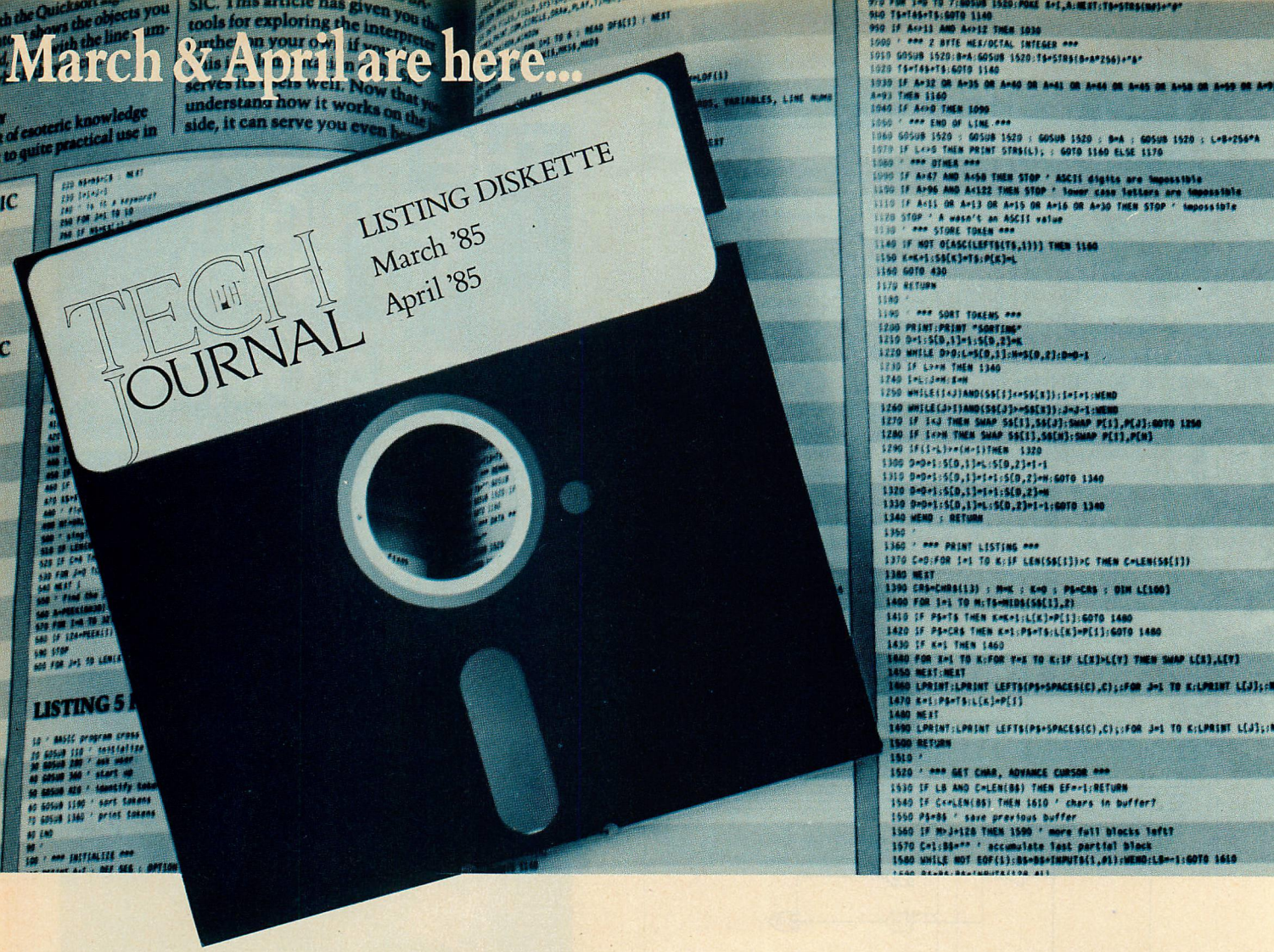
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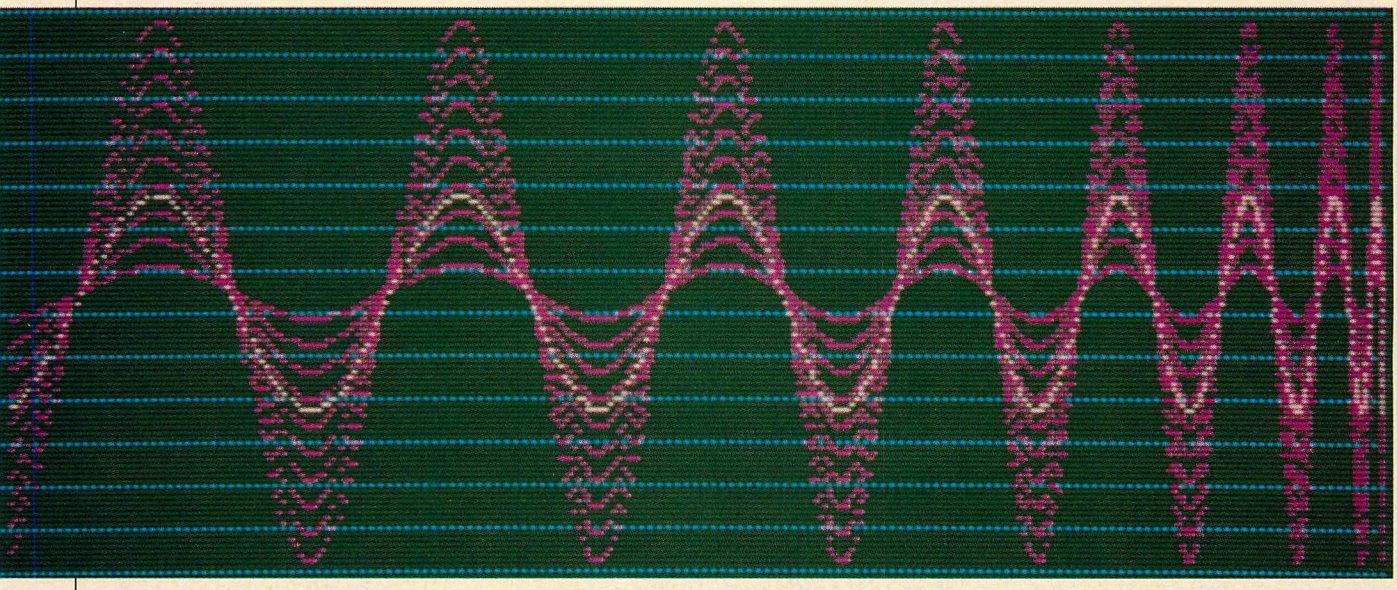
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An assembly language program for screen display of digitized waveforms

PETER G. AITKEN



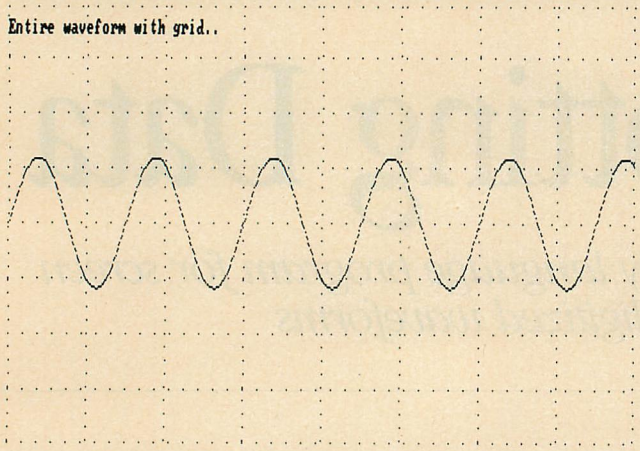
The digital computer has become a common sight in scientific and engineering laboratories. The IBM PC is a good candidate for laboratory use (see "Passing the Lab Test," Peter G. Aitken, *PC Tech Journal*, January 1984, p. 74). One common application is to interface a PC to an analog-to-digital converter (ADC) so that electrical signals can be digitized and stored in the computer's memory.

The result of such a process is usually a data array in which successive array elements contain digital numbers representing the measured signal voltage at successive time intervals. This data can be stored on disk, processed mathematically, or manipulated in other esoteric ways, such as to provide a graphic representation in which the digitized data are converted back to some sort of analog form closely resembling the original waveform. One way to do this is to use the computer monitor somewhat like an oscilloscope, where each datum is displayed as a point on the screen with the time dimension represented horizontally and the voltage represented vertically. If the computer's graphics resolution is sufficient, that is, if the points can be placed sufficiently close together, the resulting display can be virtually indistinguishable from the original signal.

Duke University Medical Center in Durham, North Carolina, has two PCs, equipped with Tecmar Lab Master boards, that are used to digitize and store waveforms from biomedical experiments. The IBM color/graphics adapter, with its 640-by-200 high-resolution graphics mode, is well-suited for this purpose (although 400-point vertical resolution would be even better). The programs used, written in BASIC, could use the PSET statement in a FOR-NEXT loop to plot data points that were stored in an array. It takes about seven seconds to plot 640 points on the screen using interpreted BASIC; compil-

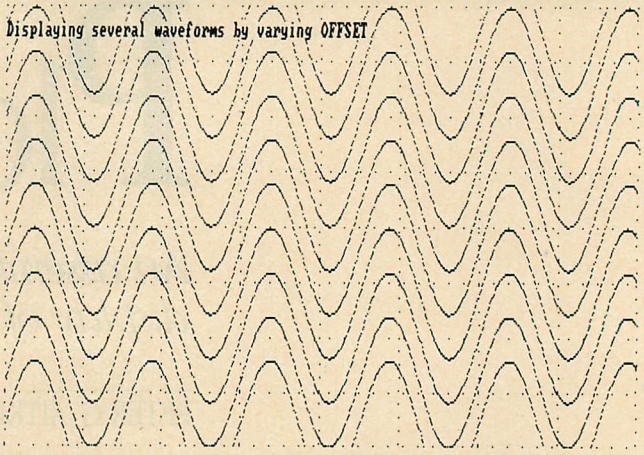
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FIGURE 1: *Waveform With Grid*



This display is produced by PLOTTEST.BAS with the grid% parameter set to a nonzero value; if it is set to zero, no grid is plotted.

FIGURE 2: *Waveforms With Offset Variations*



These waveforms were produced using PLOTTEST.BAS and varying the offset% parameter, which may be set to any integer value.

ing the program reduces this time to about two seconds. Some of the applications, however, would benefit from even faster processing. To obtain maximum speed, an assembly language routine was written to do the plotting.

The first routine was written to take advantage of one of the PC's system resources, namely the type 10H video I/O interrupt. Interrupt 10H makes writing the routine quite straightforward, because it allows access to the system's bit-mapped graphics capability from assembly language without having to deal with all of the details of the graphics board's memory. This first attempt resulted in a tenfold speed improvement over compiled BASIC.

Yet, the source listing for the type 10 interrupt in IBM's *Technical Reference Manual* shows that the code is quite inefficient when used only to clear the screen or to write a dot in high-resolution mode. By incorporating customized routines for these two functions into the plotting program, an even greater speed advantage is realized.

The subroutine PLOT.ASM, shown in listing 1, is intended to be called from a BASIC program, but it could be easily modified for use with any language. Listing 2, PLOTTEST.BAS, is a BASIC program that demonstrates the use of the PLOT subroutine.

The video mode must be set to 640-by-200 graphics by the calling program. In addition, the routine requires that six parameters, which control various aspects of the display, be passed to it by the calling program. The parameters are all integer variables, and the call is as follows:

```
CALL PLOT (grid%,clr%,offset%,
  scale%, addr%,stp% )
```

The parameters that are passed to PLOT are described below.

grid%. If grid% is set to any nonzero value, a grid of vertical and horizontal lines is plotted along with the waveform as shown in figure 1. If it is set to zero, no grid is plotted.

clr%. If clr% is set to any nonzero value the screen is cleared. If it is set to zero the screen is left undisturbed.

The subroutine PLOT.ASM, though intended to be called from BASIC, can be modified for use with any language.

This option is used to superimpose several waveforms as illustrated in figures 2, 3, and 4.

offset%. This parameter specifies the offset of the vertical zero point and is normally set in the range 0-199, but may be set to any integer value. For example, if offset% is set to 100, data values of 0 will appear centered vertically on the screen; if set to 0, data values of 0 will appear at the top of the screen. Figure 2 illustrates the effects of varying this parameter.

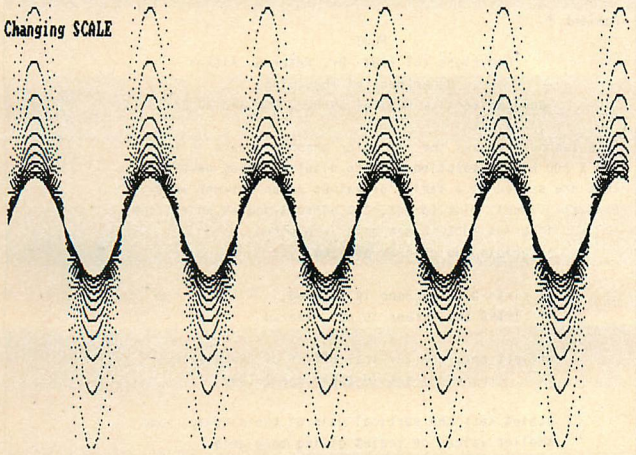
scale%. The data values are divided by scale% before being plotted. This is necessary because integer data values can range between −32,768 and +32,767, while the graphics card uses a vertical plotting range of 0-199. In addition, since the vertical coordinates of the IBM board are inverted, with larger values being plotted toward the bottom of the screen, the program inverts the data back, so that larger (positive) values are plotted at the top of the screen. If scale% is set to 0, the routine does not invert, divide, or offset the data. This is useful when the data in the array have already been converted to graphics coordinates: omitting the division step saves considerable time. Figure 3 shows the effects that can be obtained by varying scale%.

addr%. This parameter is the starting address of the data array to be plotted. The statement immediately preceding the CALL statement should be addr%=VARPTR(x%(i,j,...)), in which x%(i,j,...) is the first data array element to be plotted. For example, if a data array is dimensioned as x%(2000,2,2), then setting addr% equal to VARPTR (x%(200,2,2)) will result in elements x%(200,2,2) through x%(840,2,2) being plotted.

stp%. The horizontal resolution of the color/graphics adapter is 640 points—the maximum number of data points from one waveform that can be displayed at one time. The program allows the option of displaying fewer points, however; 320 or 160 data points may be displayed using the entire width of the screen. Stp% must be set equal to 1, 2, or 4; this value is not range-checked by the program. If set to 1, then 640 data points starting at addr% are plotted; if set to 2, then 320 are plotted; if set to 4, then 160 are plotted. In each case the plot fills the horizontal extent of the screen.

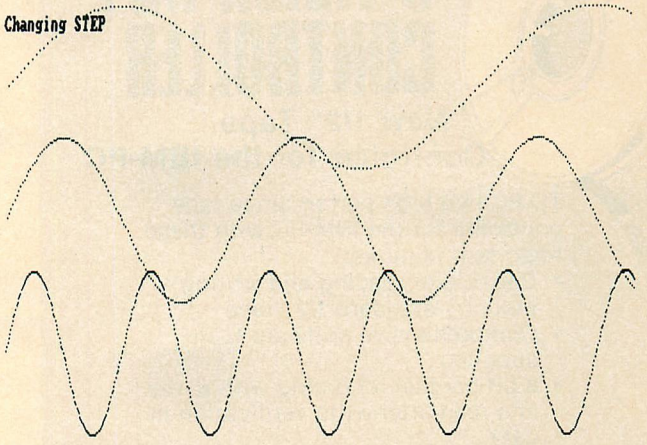
In addition to displaying waveforms collected with an ADC, the PLOT subroutine can be used to display data obtained via an RS-232 or IEEE-488 interface or data generated by some mathematical process such as process simulation. A graphics screen-dump

FIGURE 3: *Waveform With Scale Variation*



Waveforms like these can be produced using PLOTTEST.BAS and varying the value of the scale% parameter passed to PLOT.

FIGURE 4: *Waveform With Step Variation*



By setting the stp% parameter to 1, 2, or 4, waveforms with a varying number of data points can be produced with PLOTTEST.BAS.

program, such as GRAPHICS.COM supplied with PC-DOS 2.0, can be used to obtain a hard copy of the screen displays that are created by PLOT.

Execution speed could be slightly enhanced by placing the code that actually plots a point ("put_point") inside the plotting loop rather than being called as a subroutine. A call to a near procedure requires 19 clock cycles (byte operand) or 23 clock cycles (word operand), and an intrasegment return requires 20 clock cycles if the stack is not popped. Since this procedure is called 640 times, eliminating these statements could save up to 5.8 milliseconds per plot (43 clocks times 640 calls times 210 nanoseconds/clock = 5.8 ms). The range-checking of Y could also be dispensed with, if the user is confident that the data will not go outside this range, for an additional savings of up to 2.15 ms per plot. PLOT is, however, a reliable and useful program that potentially may find as much use in other circumstances and for other disciplines as it has already found in the laboratory at Duke University.

Peter G. Aitken, Ph.D., works in the department of physiology at Duke University Medical Center in Durham, North Carolina. He is a computer consultant and has written several articles for this magazine.

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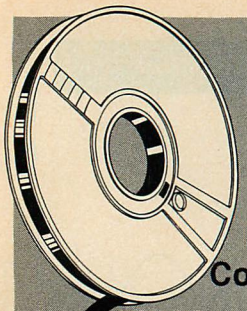
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LISTING 1: PLOT.ASM

```
comment *
                        PLOT
          Copyright (C) 1984  Dr. Peter G. Aitken
                Department of Physiology
        Duke University Medical Center, Durham, NC 27710

This subroutine uses the IBM color graphics board in the
640 X 200 high resolution mode to display analog waveforms
that are stored as a series of values in an integer array.
Format:     call plot (grid%,clr%,offset%,scale%,addr%,stp%)
        if grid%<>0 a screen grid is plotted;
        if grid%=0 no grid is plotted.

        if clr%<>0 the screen is cleared;
        if clr%=0 the screen is not cleared.

        offset% sets the vertical offset of the display;
        this is normally set in the range 0-199.

        scale% sets the vertical gain of the display, with
        smaller values of scale% giving more gain.

        addr% is the address (i.e., offset within the
        data segment) of the first array element to be
        plotted.

        stp% must equal 1, 2, or 4: it determines if
        640 (step%=1),  320 (step%=2) or 160 (step%=4)
        data points are plotted. Value  not range checked.
*
;*************************************************************
sseg            segment stack           ;set up stack
                dw      50 DUP (?)
sseg            ends
dseg            segment
                                ;set up data segment with re-
array           dw  (?)         ;served memory locations for
divisor         dw  (?)         ;the 6 parameters to be
step            dw  (?)         ;passed by the calling program.
off_set         dw  (?)
clear           dw  (?)
grid            dw  (?)
dseg            ends

video           segment at 0B800H
video           ends

cseg            segment public 'CODE'

                assume cs:cseg,ss:sseg,ds:dseg,es:video

                public  PLOT            ;declare "PLOT" public
                                        ;so it can be called
PLOT            proc    far             ;from another program.
                push    bp              ;save register

;the next block of code gets the 6 parameters passed
;by the calling program and stores them in the proper locations

                mov     bp,sp
                mov     si,[bp]+16
                mov     dx,[si]
                mov     grid,dx         ;1st parameter in GRID
                mov     si,[bp]+14
                mov     dx,[si]
                mov     clear,dx        ;2nd parameter in CLEAR
                mov     si,[bp]+12
                mov     dx,[si]
                mov     off_set,dx      ;3rd parameter in OFF_SET
                mov     si,[bp]+10
                mov     dx,[si]
                mov     divisor,dx      ;4th parameter in DIVISOR
                mov     si,[bp]+8
                mov     dx,[si]
                mov     array,dx        ;5th parameter in ARRAY
                mov     si,[bp]+6
                mov     dx,[si]
                mov     step,dx         ;6th parameter in STEP

                push    es              ;save es value
                mov     dx,0B800H       ;point es at video ram
                mov     es,dx

;if CLEAR = 0 jump ahead, if CLEAR <> 0 clear screen.
```

```
                mov     dx,clear
                cmp     dx,0
                je      no_clear

;the next 5 lines clear the screen by using the STOSW instruction
;to place 0 in all words of video memory.

                mov     cx,2000H        ;video ram word count
                mov     ax,0
                mov     di,0            ;start at offset 0
                cld                     ;set forward direction
                rep     stosw

;if GRID <>0 put a grid on the screen - else jump

no_clear:       mov     dx,grid
                cmp     dx,0
                je      no_grid

;first do horizontal grid lines

                mov     ax,199          ;plot line in row 199
                call    horiz
                mov     ax,175          ;plot line in row 175,
N1:             call    horiz           ;150, etc.
                sub     ax,25
                jns     N1              ;if dx not < 0, do another

;now do vertical grid lines

                mov     cx,639          ;plot line in column 639
                call    vert
                mov     cx,560          ;plot line in column 560,
N2:             call    vert            ;480, etc.
                sub     cx,80
                jns     N2              ;if cx not < 0, do another

;the next block of code initializes cx, which will count loops,
;and si, which is used as an offset pointer within the data array

no_grid:        mov     cx,640          ;count in cx
                mov     ax,1280         ;offset for start of plot
                cwd                     ;will be 1278 for step=1,
                idiv    step            ;638 for step=2, and 318
                mov     si,ax           ;for step=4 -
                sub     si,2

;now we start to plot

                mov     bx,array        ;put array base address
                                        ;in bx
plot_loop:      sub     cx,step         ;subtract STEP from cx;
                jcxz    done            ;if the result is less
                                        ;than 0, we're done.
                mov     ax,[bx][si]     ;get array element
                cmp     divisor,0       ;if divisor=0 jump ahead
                jz      no_div
                neg     ax              ;negate it
                cwd                     ;convert to double word
                idiv    divisor         ;divide by scaling factor
                add     ax,off_set      ;add the offset

;now ax has the row number, which can range from 0 to 199.
;The next 4 lines check to see if ax is within this range;
;if ax less than 0 or greater than 199 the point is not plotted.

no_div:         cmp     ax,0
                jl      skip
                cmp     ax,199
                jg      skip

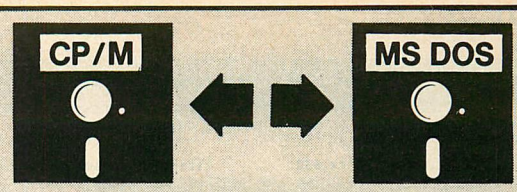
                call    put_point

skip:           sub     si,2            ;decrement data pointer
                                        ;to point at next array
                jmp     plot_loop       ; element go back and
                                        ;do another
done:           pop     es
                pop     bp
                ret     12
PLOT            endp

;*****************************************************************

;subroutines

;"horiz" places a row of dots across the screen, placing a
```

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```
;dot in every 15th column.  The calling program must pass the
;desired row number (0-199) in ax.

horiz           proc near
                mov     cx,630          ;starting column number

H1:             call    put_point

                sub     cx,15           ;decrement column number
                cmp     cx,0            ;if cx>=0 do another
                jge     H1
                ret
horiz           endp

;*************************************************************

;"vert" places a column of dots down the screen, placing a dot
;in every 6th row.  The calling program must pass the desired
;column number (0-639) in cx

vert            proc    near
                mov     ax,198          ;starting row number

V1:             call    put_point

                sub     ax,6            ;decrement row number
                cmp     ax,0            ;if ax>=0 do another
                jge     V1
                ret
vert            endp

;*************************************************************

;This subroutine puts a point on the high resolution graphics
;screen. Enter with Y (0-199) in ax, X (0-639) in cx, and es
;pointing to video ram (B800).  All registers are preserved.

put_point       proc    near

                push    si              ;save all registers used
                push    bx
                push    cx
                push    ax
                push    cx              ;save cx and ax again for
                push    ax              ;program use

                and     ax,0FEh         ;strip odd/even bit of Y
                sal     ax,1
                sal     ax,1
                sal     ax,1            ;ax=ax times 8
                mov     bx,ax
                sal     ax,1
                sal     ax,1            ;ax=ax times 32
                add     ax,bx           ;ax=ax times 40
                pop     bx              ;now bx has original ax
                sar     bx,1            ;low bit into CF
                jnb     even            ;if low bit was 0, y is
                add     ax,2000H        ;even. if odd, adjust
                                        ;for video odd row
                                        ;addresses
; now ax has 40*Y if Y is even and 40*Y+2000H if Y is odd -
;this is the address of the leftmost video byte in the row
;in which this point is to be put. We now must add (X/8) to
;get actual address

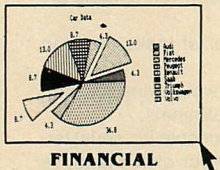
even:           sar     cx,1
                sar     cx,1
                sar     cx,1            ;cx=x/8
                add     ax,cx           ;now ax has final address
                mov     si,ax
                pop     cx              ;now cx has original x
;now to determine the bit to set
                and     cx,0007H        ;now bx has x mod 8
                mov     al,80H          ;start with mask 10000000B
                shr     al,cl           ;shift bit right to correct
                                        ;position
                or      al,es:[si]      ;put in any other bits
                                        ;that are already set in
                                        ;that byte of video ram
                mov     es:[si],al      ;put it back in video ram

                pop     ax
                pop     cx
                pop     bx
```

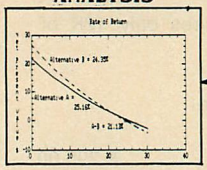

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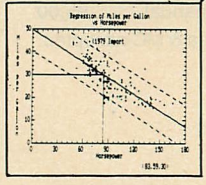
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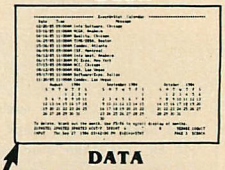


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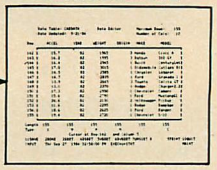
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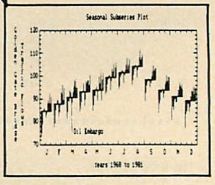
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```
                pop     si
                ret

put_point       endp
;*************************************************************
cseg            ends
                end
```

LISTING 2: PLOTTEST.BAS

```
'BASIC program to demonstrate PLOT assembly language routine.
'
'  compile: BASCOM plottest/n
'  link: LINK plottest+plot
'
40 cls : locate 15,10
   input "Color/graphics adapter needed - continue (Y/N)";k$
   if k$="N" or k$="n" goto 2000
   if k$="Y" or k$="y" goto 50 else goto 40
50 dim x%(1280) : delay=6000 : screen 2
'
55 cls : locate 18,10
   print "Now calculating waveform array..."
60 for i%=0 to 1280
          q=sin(i%*3.14/60)
          q=300*q
          x%(i%)=int(q)
   next
'
   x$="Entire waveform without grid"
   clr%=1 : grid%=0 : stp%=1 : scale%=10 : offset%=100
   gosub 1000
   gosub 1500
'
   x$="Entire waveform with grid..
   clr%=1 : grid%=1 : stp%=1 : scale%=10 : offset%=100
   gosub 1000
   gosub 1500
'
   x$="Displaying several waveforms by varying OFFSET"
   clr%=1 : grid%=1 : stp%=1 : scale%=10
   for offset%=10 to 190 step 20
   gosub 1000 : clr%=0 : next offset%
   gosub 1500
'
   x$="Changing SCALE"
   clr%=1 : grid%=0 : stp%=1 : offset%=100
   for scale%= 13 to 2 step -1
   gosub 1000 : clr%=0 : next scale%
   gosub 1500
'
   x$="Changing STEP"
   clr%=1 : grid%=0 : scale%=8 : offset%=40
   stp%=4 : gosub 1000
   stp%=2 : clr%=0 : offset%=100 : gosub 1000
   stp%=1 : clr%=0 : offset%=160 : gosub 1000
   gosub 1500
'
   x$="waveform scrolling with scale=0"
   cls : locate 2,1 : print x$
   for i%=0 to 1280
          x%(i%)=x%(i%)\6+100
   next
   gosub 1500
   clr%=1 : grid%=0 : scale%=0 : offset%=100 : stp%=1
   for i%=0 to 600 step 10
   addr%=varptr(x%(i%))
   call plot (grid%,clr%,offset%,scale%,addr%,stp%)
   next
'
   locate 24,34 : print "A=again   E=exit"
900k$=inkey$ : if k$="" then goto 900
   if k$="A" or k$="a" then goto 55
   if k$="E" or k$="e" then goto 2000 else goto 900
'
1000       addr%=varptr(x%(0))
   call plot (grid%,clr%,offset%,scale%,addr%,stp%)
   locate 2,1 : print x$ : return
'
1500'      delay loop
   for w=1 to delay
   next w
   return
'
2000       screen 0,0,0 : end
```


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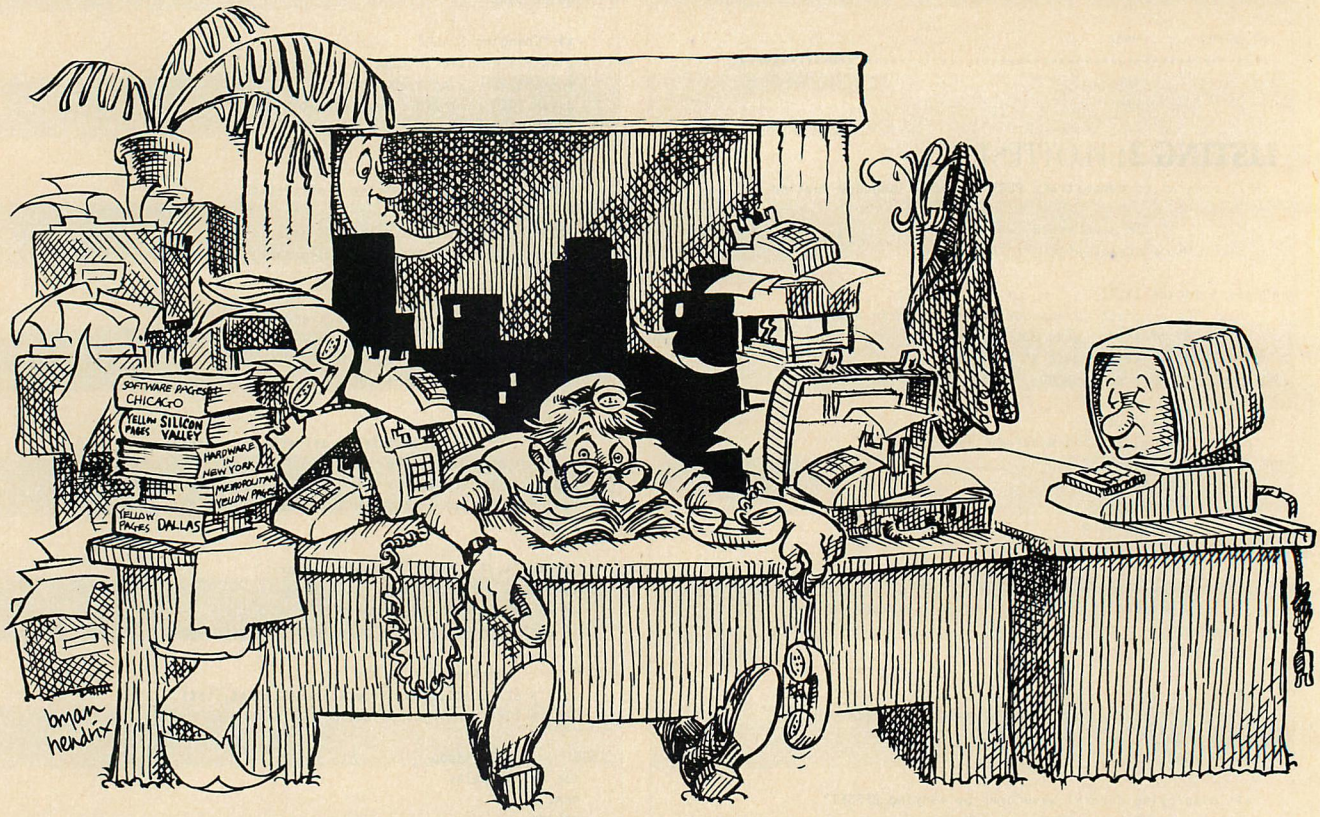
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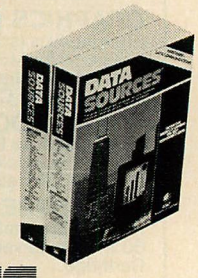
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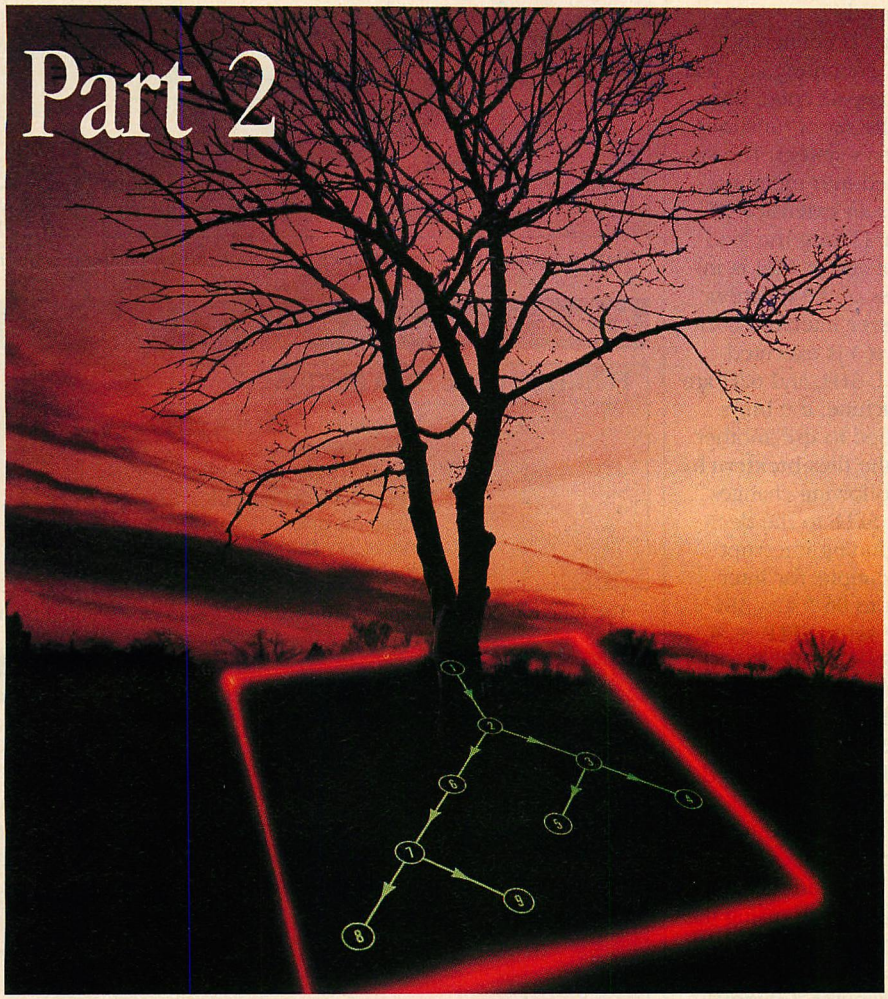
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Tree Structures

Part 2



With the complete source code presented here, the B+tree file-management system can be implemented.

ATINDRA CHATURVEDI

This is the second of two articles on using B-tree-based file management systems for random data storage and retrieval. The first, which appeared in the February issue (page 78), discussed the advantages and disadvantages of tree structures. This article presents the complete source code program, written in C language, that is needed to implement a file management system, based on B+tree structures, and its associated data access system.

The B+tree file-management system presented here, called **btsys**, provides an efficient way of organizing data by key value to allow rapid random insertion and retrieval of information in files. The **btsys** program uses the B+tree structure (see "Tree Structures," February 1984, p. 78) in an overall scheme for managing a variety of indexes to data files.

The **btsys** system gives the user a standard and simple interface to use for

PHOTOGRAPH • MARK DAVID COHEN

keyed access to data files. It also allows him to use keys of any length, control the size of nodes to vary the order of the B+tree, use the **btsys** system with programs in any language, simultaneously open any number of index files, create any number of index files for a data file, and change the various parameters built into the system to tailor the code to his needs.

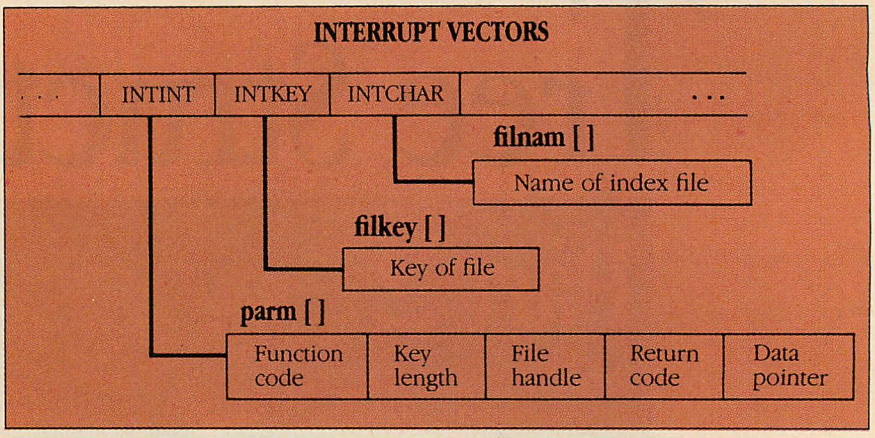
C, a language that is eminently suited for system programming and that generates fast and compact code, was used to implement the set of functions that makes up the **btsys** system. The system program is loaded into memory and made resident as an extension of the operating system. During the loading process, interrupt vector 60H is initialized to the address of the function **btsys( )**. Thus, whenever interrupt 60H occurs, function **btsys( )** is executed.

If interrupts 60H, 61H, and 62H are not available in a machine, the **btsys** system can be modified to use another set of interrupts. In the files **btextern.h** and **btglobal.h**, the following changes should be made. Set **SELF** to the decimal value of the beginning interrupt value times 4. For example, for interrupt 60H, **SELF** is set to 96 * 4 = 384. **INTCHAR** should be set to **SELF** + 4, **INTINT** to **INTCHAR** + 4, and **INTKEY** to **INTINT** + 4. **VECNO** should be set to the hex value of the interrupt number. In the file **btacslib.c**, interrupt number in the call should be adjusted to to **sysint**, and **INTCHAR**, **INTINT**, and **INTKEY** should be changed to the values that were calculated above.

Data are passed between the user program and the **btsys** system using the interface structure shown in figure 1. In the set of five parameters at the bottom of the figure, the parameter *function code* specifies the function that is to be executed by **btsys** (see table 1), and *key length* specifies the length of the key; this parameter is used only in creating the index file. A *file handle* is an integer that is returned by **btsys** when a file is opened or created. This integer is used to specify the file upon which the function is to be performed. The file handle is implemented as an index into an array of file control blocks (see figure 2) that is maintained by **btsys**.

A *return code* is returned by **btsys** after the requested function has been performed; a zero value represents successful completion. (See table 2 for a list of return codes.) A *data pointer* is returned by **btsys** if the random-read function is desired. The user program does a direct read on the data file, using the data pointer to retrieve the record with the desired key.

FIGURE 1: *Interface Structures*



Data are passed between the user program and btsys using this interface structure.

TABLE 1: *Function Codes*

FUNCTION CODE	DESCRIPTION
0	Initialize the interrupt vectors with the addresses of interface structures
1	Create a new index file
2	Open an existing index file
3	Close an open index file
4	Insert key into an index file
5	Read data pointer from the index file for the supplied key

The function code specifies the function that is to be executed by btsys.

FIGURE 2: *File-control Block Structure*

```
struct   {
         unsigned  root;                  /* # of root record */
         unsigned  handle;                /* file handle to index */
         unsigned  keylen;                /* key length of this index */
         int       *infobuf;              /* pointer to info. buffer */
         int       *filbuf;               /* pointer to file buffer */
         FILE      *fdesc;                /* stream identifier for index */
         char      *ikeyptr;              /* pointer to first key */
         char      filnam [LFILNAM + 1];  /* file name */
         char      curkey [LKEYLEN + 1];  /* current key */
         }     btfilar     [MAXFIL + 1];
```

An array of file-control blocks is used by btsys to manage information about open files.

TABLE 2: *Return Codes*

RETURN CODE	DESCRIPTION
0	Function successfully completed
1	Read error on an index file
2	Write error on an index file
3	File seek error on an index file
4	File open error
5	File close error
6	File logic error 61—file not open 62—file already open 62—maximum number of files open
7	No available memory
8	Error in releasing memory
9	Index file full
10	Unknown function code

A return code is returned by btsys after the requested function has been performed.

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TREE STRUCTURES

The structure created by these five parameters is implemented, in the form of an array of five integers, as **parm[ ]** in the **btsys** access-library function.

The next parameter—**filkey[ ]**—specifies the key of the data record for which the data pointer to the data file record is to be retrieved or which is to be inserted into the index file. This structure is implemented, in the form of a character array of length **LKEYLEN + 1**, as **filkey[LKEYLEN + 1]** in the **btsys** access-library function.

The **filnam[ ]** parameter indicates the file name of the index file. This file name can be any valid DOS file name, with or without a drive specifier; paths are currently not implemented. The file name is used only to create or open a new index file. The structure of the file name is implemented, in the form of an array of characters of length **LFILNAM + 1**, as **filnam[LFILNAM + 1]** in the **btsys** access library.

When the user executes function 0 using the **btsys( )** function, the user program gives that function the addresses of the three interface structures in the access library. This initializes the interrupt vectors **INTINT**, **INTKEY**, and **INTCHAR** (defined in the header file **btglobal.h**) to the addresses of **parm[ ]**, **filkey[ ]**, and **filnam[ ]**, respectively.

Once the initialization is accomplished, the interface data structures can be accessed by retrieving the data indirectly via the address in the appropriate interrupt vector. This function is performed by **btparm( )**, which retrieves the data passed to the **btsys( )** function by the user.

The function **btexport** returns values from the **btsys( )** function after the desired function has been completed.

INDEX FILE ORGANIZATION

The index file generated by the **btsys( )** function consists of records that are **LBLEN** bytes long. Record 0 of the file is an index-information record. Its structure is shown in table 3.

Each record from record 1 onward is used to hold one node of the B+tree structure. Each key value stored in the node is associated with an integer pointer (see table 3). Thus, key length + 3 bytes is required to hold all the information for one key in the node. In every node, the last byte is used to store a flag. If the flag is 'Y,' the node contains pointers to data records (leaf node); if it is 'N,' the node has pointers to other nodes (nonleaf).

In each node that is **LBLEN** bytes long, the keys, pointers, and flag should be arranged according to the following three rules:

TABLE 3: *Index File Record Structure*

RECORD 0 STRUCTURE

BYTES	CONTENTS
0–1	Unsigned integer containing current root record number
2–3	Key length for this index
4–5	Last allocated record number
6–LBLEN	Unused

NODE RECORD STRUCTURE REQUIREMENTS PER KEY

SIZE	CONTENTS
Key length	Key value
1	Terminating null
2	Integer pointer

The index file generated by the btsys( ) function consists of records that are LBLEN bytes long. Each key value stored in the node is associated with an integer pointer.

1. The number of bytes that are available for storing keys and pointers = **LBLEN** − 1 (for flag).
2. The size of key information (key + pointer) = key length + 3.
3. The number of occurrences of keys (or pointers) in a node that is **LBLEN** bytes long = (**LBLEN** − 1) / (key length + 3).

For example, if the node size is 1,024 bytes (**LBLEN** = 1,024) and the key length is 10 bytes, then the number of bytes that is available for keys and pointers is 1,023, the size of key information is 13 (10 + 3) bytes, and the number of occurrences of keys in the node is 78 (1,023 / 13).

As shown above, the B+tree-structure implementation used here defines fixed-length nodes, with the order of the resulting B+tree depending on the size of the keys in the nodes.

In order to allow the **btsys** system to cope with keys of varying lengths in different index files, file-control blocks are used to hold relevant data about an index file while it is open. An array of file-control blocks is managed by the **btsys** system. The file handle that is returned after a create or open request is an index into this array.

A create or open request to the **btsys** system puts in motion the following sequence of events. First, the array of file-control blocks is scanned in order to find an unused control block. If found, the block is assigned to the current open or create request; if one is not found, an error code is returned. Next, the operating system is called in order to obtain two blocks of memory for use as file buffers, each **LBLEN** bytes long. The variable **infobuf** in the file-control block is then assigned the address of one of the buffers that have just been created. This buffer is used to store record 0 of each index file.

Next, the variable **filbuf** in the file-control block is assigned the address of the remaining buffer. Any I/O on the index file using the file handle is done via this buffer. The variable **ikeyptr** is then set to hold a character pointer to the first key in the file I/O buffer. This pointer is used to manipulate keys during operations on the B+tree.

As the next step, the variable **filhand** is assigned the index value of the file-control block to allocate the control block to the index file. Finally, the variable **fdesc** is assigned the stream identifier that is returned by the **btopen** function's call to **fopen.** This variable is used subsequently by **btwrit** and **btread** functions to do I/O on the index file and by **fclose** to close the index file.

The index file is opened in the update mode as a binary file. All I/O uses standard I/O library functions (see Kernighan and Ritchie, *The C Programming Language*). Memory allocation uses **calloc** and **free** functions.

When an index file is closed, the file-control block is released by assigning the value NULL to the variable handle. The two file buffers are also returned to the operating system.

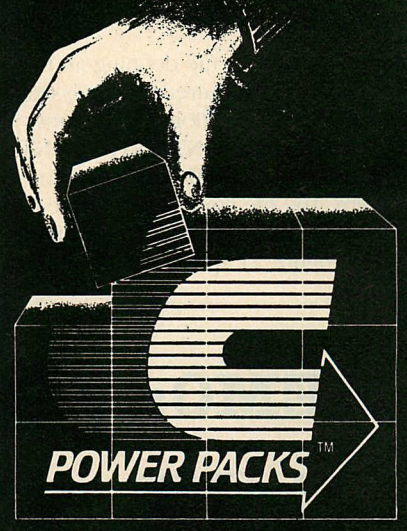
SOURCE CODE FOR BTSYS

The object modules are created using the Computer Innovations C-86 compiler version 1.33. All compiled modules except for **bttest.o, btuse.o,** and **btsetup.o** are then put into a library named **btsyslib.cl** using the **LIBR** object librarian program. They were then linked using the following commands:

```
CL btsetup btsyslib clib
CL btuse btsyslib clib
CL bttest btsyslib clib
```

The library supplied with the C-86 compiler is **clib**, and CL is the link program for the C-86 compiler.

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The following is a detailed description of all the functions that comprise the file management system, **btsys**:

btglobal.h (listing 1)
Input: None
Output: None
Function: Header file defining all the global areas required by the system.
Description: Definitions of constant values, such as **INTINT**, **INTKEY**, **INTCHAR** and **MAXFIL**, are available here. The file control blocks are defined as an array of structure **btfilar** (see figure 2). Integer and character pointers—*ip1, *ip2, *ip3, *cp1, *cp2, and *cp3—are defined to allow their use in every key- and pointer-manipulation routine in the system. A macro BTSETCOD(x,y,z) is used to set the file handle and data pointer and to return the return code to the calling function.

btread.c (listing 2)
Input: File handle, data pointer
Output: Return code
Function: Reads a record specified by the data pointer from the index file specified by the file handle.
Description: The offset of the first byte to be read is calculated by multiplying the record number to be read by the size of a node. A seek to the calculated byte value is performed on the file, using **fseek**. After a successful seek, **fread** is used to read the record **LBLEN** bytes long into the buffer at address **filbuf** in the control block, using the stream identifier **fdesc**.

btwrit.c (listing 3)
Input: File handle, data pointer
Output: Return code
Function: Writes a record specified by the data pointer into the index file specified by the file handle.
Description: The offset of the first byte to be written is calculated by multiplying the record number to be written by the size of the node. A seek to the calculated byte value is then performed on the file, using **fseek**. After a successful seek, **fwrite** is used to write the record **LBLEN** bytes long from the buffer at address **filbuf** in the control block, using the stream identifier **fdesc**.

btstack.c (listing 4)
Input: Value to be pushed on the stack
Output: Value popped from the stack
Function: **push(f)**, **pop( )**, **and clear( )** are the functions implemented to handle the stack manipulation required by the system. These functions are based on routines from Kernighan and Ritchie's book, *The C Programming Language* (p. 75).
Description: **push(f)** pushes the value *f* onto the stack and checks for stack overflow. The function **pop( )** pops a value from the top of the stack and checks for stack underflow. The function **clear( )** resets the stack pointer and pushes two NULL values to simulate the root record values on the stack. These are used in the main system routines in order to identify whether or not an action has to be taken on the root node.

btgetsp.c (listing 5)
Input: File handle
Output: New handle record number
Function: Used to obtain a record number when a new node must be placed in the index file because a node split has taken place.
Description: Accesses the last allocated record number in the index information record, increments and returns it as the record number to be used for writing the new node.

btopnkt.c (listing 6)
Input: None
Output: Index to an unused file-control block
Function: Returns a file handle as an index into the file-control block array.

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Description: Accesses the file-control-block array **btfilar** to find one whose variable-handle value is equal to NULL. The index to this control block is returned as the file handle.

btcreat.c (listing 7)

Input: Valid DOS file name

Output: Return code

Function: Creates an index file of the specified name, sets up the file buffers, the index information record, and the file-control block; returns the file handle to the global areas.

*The function **btparm.c** is used to obtain the parameters placed by the access library in the arrays **parm[]**, **filkey[]**, and **filnam[]** and then place them in the system global areas.*

Description: The file with the specified name is created. A file-control block, a file buffer, and an index information record buffer are obtained. The file-control block is then initialized. The index information record is initialized with the value of the root record, the key length, and the value of the available record counter. It is moved to the file buffer and written to disk as record 0 of the index file. The file-control block is initialized with the value of the address of the start of the first key. The pointer area is initialized to NULL, and the key area is initialized to null strings. The flag in the last byte of the node is set to 'Y,' indicating that the node contains pointers to data. The root record is written as record 1 of the index file. The index to the acquired control block is returned as the file handle. The return code is also set.

btparm.c (listing 8)

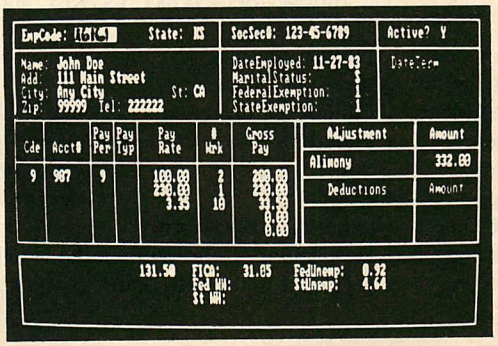
Input: None

Output: Return code

Function: Obtains the parameters that were placed by the access library in the arrays **parm[ ]**, **filkey[ ]**, and **filnam[ ]** and then places them in the system global areas.

Description: **btparm.c** obtains the code of the function requested from the address stored at interrupt vector **INTINT**. Depending on the function code, further peeks are done to retrieve the other values passed to the

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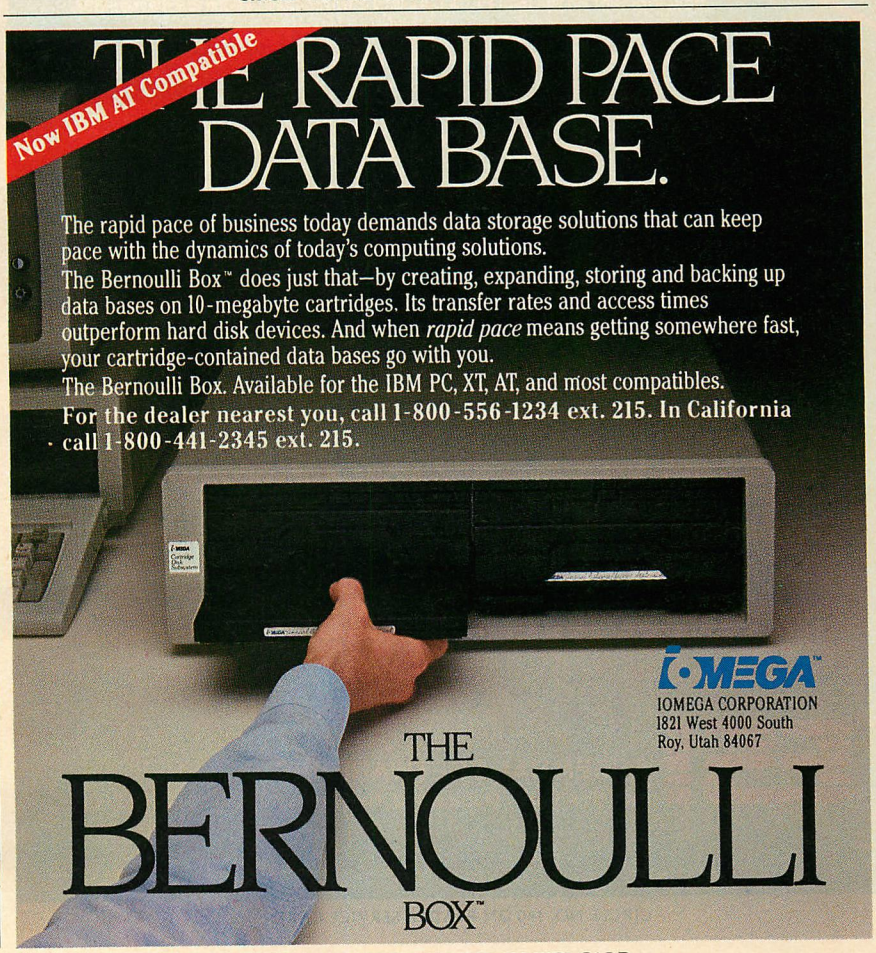
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system and to place them in the global areas. If the function code value is invalid, a return code is set.

btexport.c (listing 9)
Input: None
Output: None
Function: Moves the values returned by the system functions from the global areas to the interface structures.
Description: If the return code in the global area is nonzero, the value is sent out to the array **parm[ ]**. If the return code is zero, then depending on the function code, the appropriate values are poked into the array **parm[ ]**. The addresses of the interface structures are available in the interrupt vectors **INTINT**, **INTKEY**, and **INTCHAR**.

btclose.c (listing 10)
Input: File handle
Output: Return code
Function: Closes the index file that is specified by the file handle and releases the file buffers and control block to the system.
Description: If the value of the variable handle in the file-control block is NULL, the file is not open and an appropriate error code is returned. The index information record is moved to the file buffer and written to disk. The index information record areas and the file-buffer memory areas are released to the operating system. The file-control block is released by setting the value of the handle to NULL. The index file is then closed, using the function **fclose**.

btopen.c (listing 11)
Input: Any valid DOS file name
Output: Return code
Function: Opens an existing index file with the specified name.
Description: The file is opened as a binary file in the update mode. If the file does not exist, an error code is returned. The function **btopnkt( )** provides a file handle. Memory is obtained to hold the index information record and the file buffer. Record 0 of the index file, which is the index information record, is read from the file and moved into the index information record buffer. The file-control block is initialized. The root record number is obtained from the index information record and used to read the root record of the index file into the file buffer.

When an insertion is desired in the index file specified by the file handle, ***btsys*** *is used to traverse the B+tree to find a leaf where a record can be inserted.*

btsys.c (listing 12)
Input: None
Output: None
Function: Operates as the controlling function for the **btsys** system. It is invoked when interrupt 60H occurs.
Description: Function **btparm( )** obtains information passed in the interface structures. A switch statement is used to transfer to various functions, depending on the value of the function code. Function **btexport( )** returns the values from the global area to the interface structures.

btplace.c (listing 13)
Input: File handle, value of key
Output: Return code
Function: When an insertion is desired in the index file specified by the file

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handle, this routine is used to traverse the B+tree to find a leaf where a record can be inserted. During the traversal of the tree, a stack is used to "remember" the path taken.

Description: The key length and the root record number are obtained from the file-control block. The order of the B+tree is calculated using the size of the node and the length of the key. The B+tree is traversed starting at the root node. At each level, the desired key value is matched against the keys stored in the node. If the desired key is equal to or less than a key in the node, its corresponding pointer is used to read a node at the next lower level in the B+tree.

The previous node number and the insertion place is stored in the stack. If a leaf node is encountered, the place to insert the key is found and the procedure is exited after the node number and insertion point has been pushed on the stack.

btired.c (listing 14)

Input: File handle, value of key

Output: Return code

Function: Provides the random-read function capability. Given the value of the key and the file handle of the index file, this function traverses the B+tree structure in order to locate the data pointer to the record with the desired key.

Description: The key length of the keys in the index file and the number of the root record in the file are obtained from the file-control block. The order of the B+tree is calculated using the size of the node and the key length.

The root record is read using the value obtained from the file-control block. The tree is then traversed, using the pointer to the node records. If the node is not a leaf, the flag in the node has the value 'N.' In this case, the required key is matched against the values in the node. If the required key is equal to or less than a key in the node, the pointer associated with that key is used to read a node in the next level of the tree.

If the node is a leaf, the flag in the node has the value 'Y.' In this case, the required key is matched against the keys in the node. If a match is discovered, then the pointer associated with that key is returned as the data pointer; otherwise, the key is not in the index file, and the appropriate return code is set.

btisrt.c (listing 15)

Input: File handle, value of key, data pointer

Output: Return code

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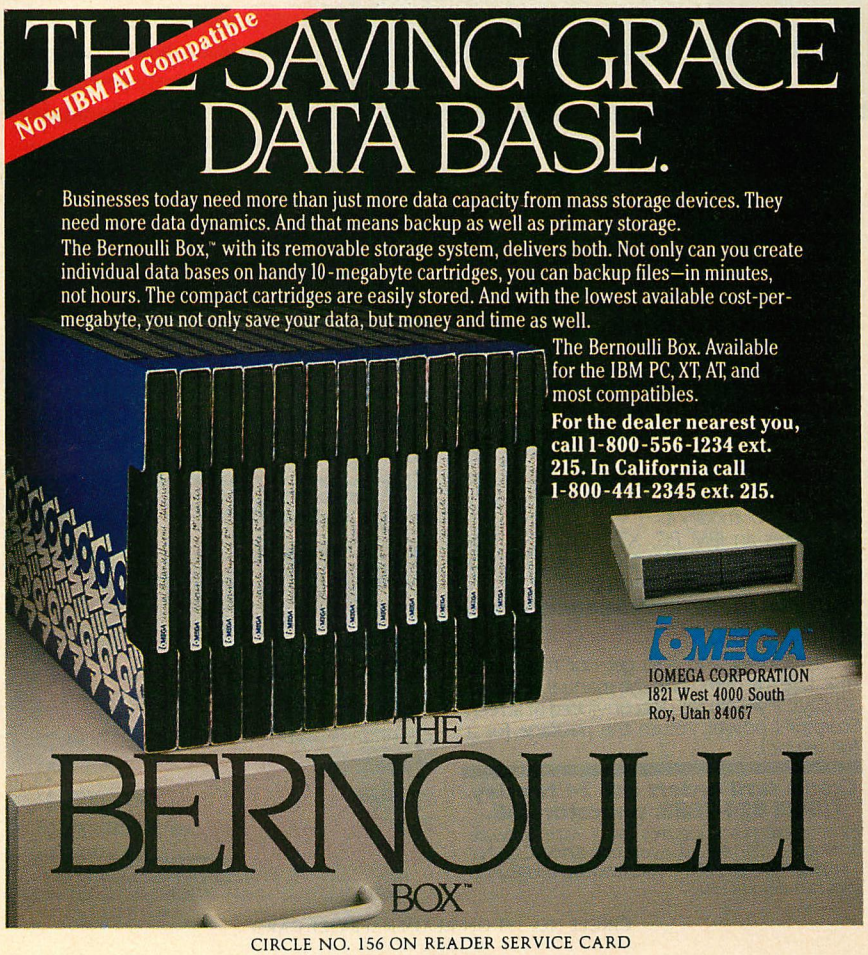
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Function: Provides the capability to insert a key and its corresponding data pointer into the index file specified by the file handle. This function is based on the descriptions found in Lewis, *Pascal Programming for the Apple* and in Lewis and Smith, *Applying Data Structures.*

Description: Function **btplace( )** is called to find a place to insert the key. The key length is obtained from the file-control block, and the order of the B+tree is calculated using the key length and the size of the node.

The stack is popped twice to obtain the node number and the insertion place in the node. The keys and pointers to the right of the specified insertion place are shifted by one position. The desired key and data pointer are inserted into the node. If no node overflow has taken place, the node is written to disk and the procedure is exited.

If node overflow has taken place, a block of memory of size **LBLEN** is acquired to store the new node that will be created. Keys and pointers in the old node, to the right of the insertion place, are moved to the new node. The area in the old node from which the keys and pointers were moved is cleared.

A new node number is obtained for the new node, which is then written out to disk. The node that was split is also written to disk.

The stack is then popped twice. If the values on the stack are NULL, the root node was split; a new root is then created by moving appropriate keys and pointers into it, obtaining a new record number for it, writing it out, and updating the index information record with the new root node record number.

If the values popped from the stack are not NULL, a nonroot node was split, and the "middle" key from the split node must be moved up and inserted into the node at the next higher level.

If the values popped from the stack are not NULL, a nonroot node was split, and the "middle" key from the split node must be inserted into the node at the next higher level.

This procedure is followed until either no node split takes place on an insertion of a key into a node or the root node is split.

BTSYS ACCESS LIBRARY

The following is a description of all the functions comprising the **btsys** access library. The interface structures **parm[ ]**, **filnam[ ]**, and **filkey[ ]** are defined as external static arrays so that the user program is shielded from knowing any details about the interface. Communication with the user program is via the global structure **btstruct.**

btinit (first part of listing 16)

Input: None

Output: None

Function: Pokes the addresses of the interface structures into the interrupt vectors.

Description: Pokes the address of **parm[ ]** into the interrupt vector **INTINT**. Pokes the address of **filkey[ ]** into the interrupt vector **INTKEY**. Pokes the address of **filnam[ ]** into the interrupt vector **INTCHAR**.



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This function is defined as a static function, so it is not visible outside of this source file.

btintr (second part of listing 16)
Input: None
Output: None
Function: Invokes interrupt 60H.
Description: This function is defined as a static function, so it is not visible outside of this source file.

btfunc (third part of listing 16)
Input: Structure **btstruct**
Output: Return code
Function: This is the access function visible to any user program. It is used to request a function from the **btsys** system after the parameters are placed in the structure **btsrtuct.**
Description: The function **btfunc** sets the interface structures **parm[ ]**, **filkey[ ]**, and **filnam[ ]** to the values that are provided in the structure **btstruct.** The function **btintr( )** is called in order to execute the **btsys** interrupt. After completion of the interrupt, values are retrieved from **parm[ ]** and placed in the structure **btstruct** for the user program.

The first 16 listings are described above with the functions they contain. Listing 17, **bttest.c**, contains a sample program. It creates a file called **testfile.idx** on drive B: and then prompts for three-byte starting and ending key values to be inserted into the file. These key values are used to create a file that contains key values in the specified range. The file is then accessed sequentially in order to retrieve the keys and print out the values.

Listing 18, **btuse.c**, is a rudimentary sample program that exercises all of the functions of the **btsys** system. It prompts for input at each step. The first function executed should be zero to initialize the system. Up to four files can be open simultaneously, but this number can be changed.

Listing 19, **btsetup.c**, is used to create the load module for the **btsys** system, as described in the program-creation instructions. When it is run, the program installs **btsys** in memory.

Several warnings should be given at this point. First, a value of zero should not be used for the value of a data pointer. Second, all the files opened in the user program must be closed before the program terminates. Failure to do this may result in loss of data. Third, a record should not be inserted into or read from a closed index file. This problem can be remedied by checking the value of the file handle against the open files before entering the switch statement in the **btsys( )** function.

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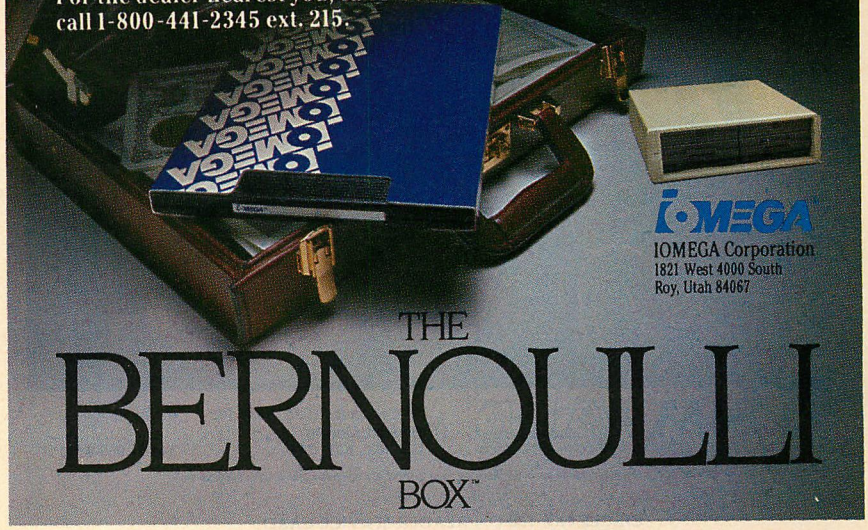
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HINTS FOR USING BTSYS

The user should experiment with the values of the constants, especially **LBLEN**. For example, A value of 1,024 bytes should generate B+trees of a high order for efficient searching.

If the node size used is very large, a binary search for keys in a node may be better than the linear search used in this implementation.

Maximum key size can be easily adjusted by changing the value of **LKEYLEN** in the header file and the access library.

The user could try increasing the maximum number of files that are open simultaneously by increasing the value of **MAXFIL**. I have been quite profligate in the use of interrupt vectors. If some simple changes were made to the source code, one interrupt vector would probably be sufficient to hold the address of the interface structures.

A least-recently-used (LRU) record-buffering scheme may be used for better throughput, although it will use more memory. A simple change is to keep the root node in core at all times, because any traversal of the tree must start at the root node.

The source program described in this article forms a good vehicle for testing various search algorithms and, with some of the ideas presented above, should form the basis of a sophisticated file management system.

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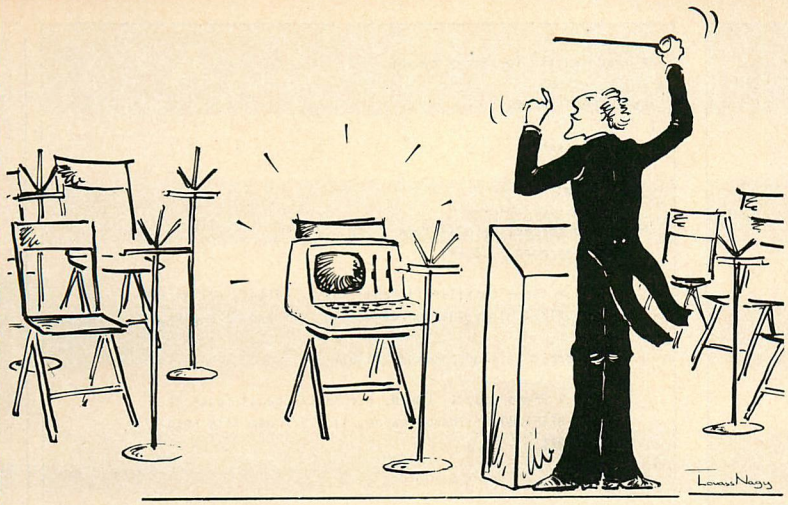
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CIRCLE NO. 110 ON READER SERVICE CARD

LISTING 1: btglobal.h

```
/*   global stuff for all modules in btsys */

#define BTSETCOD(x,y,z) {  gfilhand = x;\
                    gdatapt = y;\
                    return(z);  }

#define SELF 384
#define INTCHAR 388
#define INTINT 392
#define INTKEY 396
#define LFILNAM 14
#define LBLEN 80
#define MAXFIL 4
#define SETUP 0x31
#define VECNO 0x60
#define STACKS 0x80
#define PARAS 4096
#define LKEYLEN 16

    int     openkt, /* # of open files      */
            gorder, /* order of btree       */
            gfcode, /* function code        */
            gfilhand,       /* file handle  */
            gkeylen,        /* key length   */
            gretcode,       /* return code  */
            gdatapt;        /*data pointer  */
    char    gfilnam[LFILNAM + 1],/* file name */
            gfilkey[LKEYLEN + 1] /* file key */
    ;

    int     *ip1, *ip2, *ip3;
    char    *cp1, *cp2, *cp3;

    struct  {
                    unsigned        root;
                    unsigned        handle;
                    unsigned        keylen;
                    int             *infobuf;
                    int             *filbuf;
                    FILE            *fdesc;
                    char            *ikeyptr;
                    char            filnam[LFILNAM + 1];
                    char            curkey[LKEYLEN + 1];
            }       btfilar[MAXFIL + 1];

    FILE    *fp, *fopen();
    char    *calloc();

/* end of global   */
```

LISTING 2: btread.c

```
/* btread          */
#include <stdio.h>
#include <btextern.h>

int btread (filhand, recno)

/* read routine for btree system   */

int filhand, recno;
{
    long offset;
    int i;
    char *cp;

/* seek to correct byte in file    */
    offset = recno * LBLEN;

    if (( i = fseek (btfilar[filhand].fdesc, offset, 0)) == -1)
            BTSETCOD (filhand, recno, 3);   /* bad file seek */

    cp = (char *)btfilar[filhand].filbuf;

    if (!(i = fread (cp, 1, LBLEN, btfilar[filhand].fdesc)))
            BTSETCOD (filhand, recno, 1);   /* bad file read */
    return (0);
}
/* end of btread    */
```

LISTING 3: btwrit.c

```
/*    btwrit        */
#include <stdio.h>
#include <btextern.h>
int btwrit (filhand, recno)
    int filhand, recno;
{
    long offset;
    int i;
    char *cp;

/* seek to correct byte in record          */
    offset = recno * LBLEN;
    if (( i = fseek (btfilar[filhand].fdesc, offset, 0)) == -1)
            BTSETCOD (filhand, recno, 3);   /* bad file seek */

    cp = (char *)btfilar[filhand].filbuf;

    if (!( i = fwrite (cp, 1, LBLEN, btfilar[filhand].fdesc)))
            BTSETCOD (filhand, recno, 2);   /* bad write */
    return (0);
}
/*    end of btwrit*/
```

LISTING 4: btstack.c

```
/* btstack         */
#include <stdio.h>
#include <btextern.h>

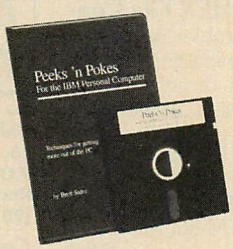
/* stack manipulation routines for the btree system*/

#define MAXVAL 50  /* maximum depth of val stack */
```

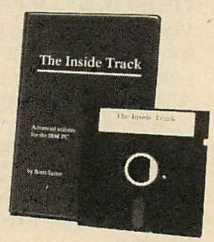

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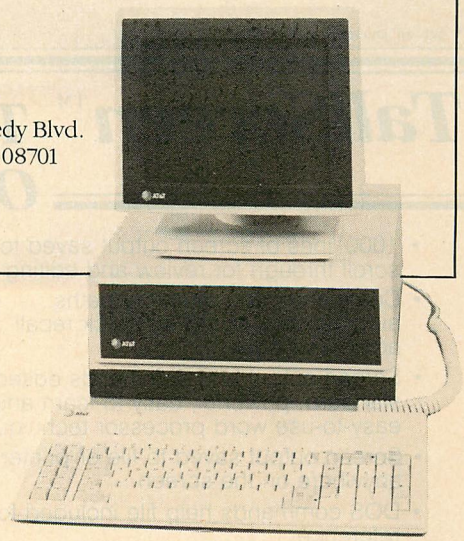
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```
static int sp = 0; /* stack pointer */
static int val[MAXVAL]; /* value stack   */

int push (f)        /* push f onto value stack */
int f;

{
    if (sp < MAXVAL)
            return (val[sp++] = f);
    else    {
            abort ("ERROR: stack full");
            clear ();
            return (0);
    }
}

int pop ()          /* pop top value from stack */

{
    if (sp > 0)
            return (val[--sp]);
    else    {
            abort ("ERR0R: stack empty");
            clear ();
            return (0);
    }
}

int clear ()                /* clear stack */

{
    sp = 0;
    push (NULL);
    push (NULL);
}
```

LISTING 5: btgetsp.c

```
/* btgetsp          */
#include <stdio.h>
#include <btextern.h>
int btgetsp (filhand)
int filhand;

/* gets a node number for a new node       */
{
    ip2 = btfilar[filhand].infobuf + 2;
    return (++*ip2);        /* increment the current value */
}
/*   end of btgetsp    */
```

LISTING 6: btopnkt.c

```
/* btopnkt          */
#include <stdio.h>
#include <btextern.h>

int btopnkt ()

/* get an unused control block     */
{
    int i;
    for (i = 1; i <= MAXFIL; ++i) {
            if (btfilar[i].handle == NULL)
            return (i);
    }       /* end for */
    return ((i > MAXFIL)? - 1 : i);
}
/*   end of btopnkt*/
```

LISTING 7: btcreat.c

```
/* btcreat */
#include <stdio.h>
#include <btextern.h>

int btcreat (filnam)
char filnam[];

/* create new instance of an index */
{
    int i, occurs, ptrarea, keyarea, *ip, left;
    char *cp;

    if ((fp = fopen(filnam, "wrb")) == NULL)
    BTSETCOD (NULL, NULL, 4);       /* file open error */
    if ((openkt = btopnkt ()) == -1)
    BTSETCOD (openkt, NULL, 63);    /* no control block */
    if (!(btfilar[openkt].infobuf =
    (int *)calloc (LBLEN, sizeof (char))))
    BTSETCOD (openkt, NULL, 7);     /* no memory */
    if (!(btfilar[openkt].filbuf =
    (int *)calloc (LBLEN, sizeof (char))))
    BTSETCOD (openkt, NULL, 7);     /* no memory */
    strcpy (btfilar[openkt].curkey,"                ");
    btfilar[openkt].keylen = gkeylen;
    strcpy (btfilar[openkt].filnam, gfilnam);
    btfilar[openkt].handle = openkt;
    btfilar[openkt].root = 1;
    btfilar[openkt].fdesc = fp;

/* initialize info index record    */
    ip = btfilar[openkt].infobuf;
    *ip++ = 1;              /*value of root record */
    *ip++ = gkeylen;        /*set key length */
    *ip = 1;                /*rec # 1 unavailable */

/* now initialize rest with zeros  */
    left = 1 + (LBLEN / 2 - 3);     /* left to be initialized */
    while (--left)
    *++ip = 0;              /* rest are available */
    movmem ((char *)btfilar[openkt].infobuf,
    (char *)btfilar[openkt].filbuf, LBLEN);
/* write index info record from buffer */
    if (( i = btwrit (openkt,0)))
    BTSETCOD (openkt,0,i);  /* set write error */

/* now initialize root record */
    occurs = (LBLEN - 1) / (gkeylen + 3);
    btfilar[openkt].ikeyptr =
```


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```
    (char *)(btfilar[openkt].filbuf + occurs);

/* initialize pointer area with NULL */
    ip = btfilar[openkt].filbuf;
    ip3 = ip + occurs;
    while (ip < ip3)
    *ip++ = NULL;

/* intialize keyarea with null strings     */
    cp = btfilar[openkt].ikeyptr;  /* initialize pointer */
    cp3 = (char *) btfilar[openkt].filbuf + LBLEN;
    while (cp < cp3)
   *cp++ = '\0';

/* initialize flag to pointer to data */
    cp = (char *) btfilar[openkt].filbuf;
    cp += (LBLEN - 1);
    *cp = 'Y';

/* write root record       */
    if (( i = btwrit (openkt, 1)))
   BTSETCOD (openkt, 1, i);        /* set write error */

/* return value to outside world */
    gfilhand = openkt;
    gretcode = 0;
    return (0);
}
/* end of btcreat */
```

LISTING 8: btparm.c

```
/* btparm          */
#include <stdio.h>
#include <btextern.h>

/*  gets parameters stored at INTINT, INTCHAR, INTKEY      */

int btparm ()
{
   int     *ip, i;
   char    *cp;
   struct  {
           int cs, ss, ds, es;
           } segreg, *segregp;

   int fromoff,    /* from offset */
       fromseg,    /* from segment */
      *tooff,      /* to offset */
       toseg;      /* to segment */

/* get function code at INTINT     */
gfcode=peek(peek(INTINT,0),peek(INTINT+sizeof(int),0));
switch     (gfcode)        {
case 1 :                   /* file create and open */
case 2 : segread(&segreg); /* get registers */
   fromoff = peek(INTCHAR,0);      /* offset of file name */
   fromseg = peek(INTCHAR + sizeof(int),0);/*seg of filname*/
   tooff = gfilnam;        /* offset of to filename */
   toseg = segreg.ds;      /* data segment of global */
   movblock(fromoff,fromseg,tooff,toseg,LFILNAM + 1);
/* now file name has been moved    */

/* now move keylength      */
fromoff = peek(INTINT,0) + sizeof(int);
gkeylen = peek(fromoff,peek(INTINT + sizeof(int),0));
break;

case 3:             /* close a file */
case 4:             /* insert a key */
case 5:             /* random read  */
segread (&segreg); /* get registers */
fromoff = peek (INTINT, 0) + sizeof (int);
gkeylen = peek(fromoff, peek (INTINT + sizeof (int), 0));
fromoff = peek (INTINT, 0) + 2 * sizeof (int);
gfilhand = peek (fromoff, peek (INTINT + sizeof (int), 0));
fromoff = peek (INTINT, 0) + 4 * sizeof (int);
gdatapt = peek (fromoff, peek (INTINT + sizeof (int), 0));

/* now get new key value   */
fromoff = peek (INTKEY, 0);
fromseg = peek (INTKEY + sizeof (int), 0);
tooff = gfilkey;
toseg = segreg.ds;
movblock (fromoff, fromseg, tooff, toseg, LKEYLEN + 1);
break;

default:            /* baaaaad function code man ! */
   gfcode = 0;
   BTSETCOD (NULL, NULL, 10);      /* bad function code */
   break;
}
/* end of switch */
return (0);            /* no problem */
}
/* end of btparm */
```

LISTING 9: btexport.c

```
/* btexport        */
#include <stdio.h>
#include <btextern.h>
int btexport ()

/* send values to outside world    */

{
   int offset, seg;

/* check if return code is bad */

if (gretcode) {             /* yes me bad ! */
   offset = peek (INTINT, 0) + 2 * sizeof (int);
   seg = peek (INTINT + sizeof (int), 0);
   pokew (offset, seg, NULL);      /* poke NULL filehandle */

   offset += sizeof (int);
   pokew (offset, seg, gretcode);  /* poke bad return code */

   offset += sizeof (int);
```


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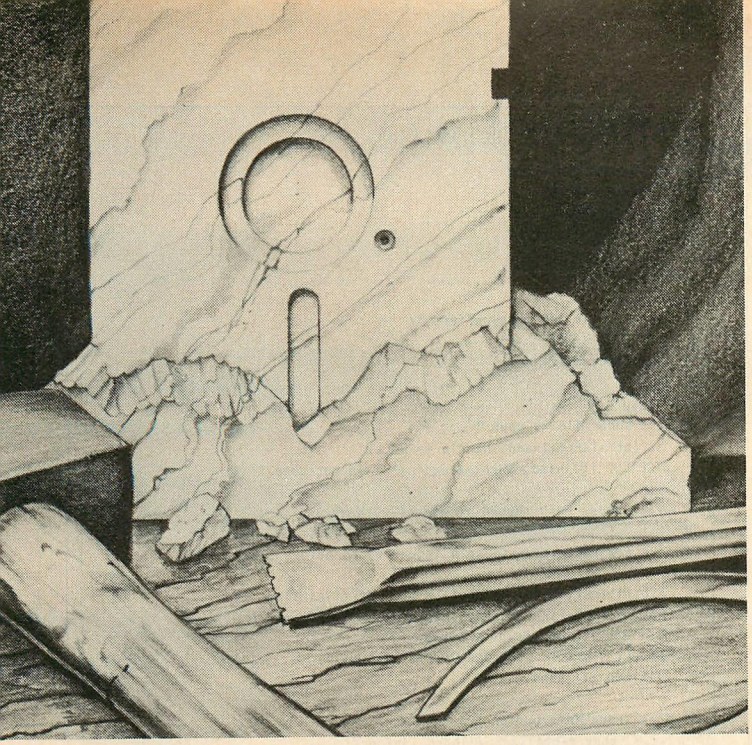
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TM

POLYTRON

```
    pokew (offset, seg, NULL);      /* poke null data pointer */

    return;                         /* out of btsys */

}  /* end if */
switch (gfcode)    {
case 1 :
case 2 :
    offset = peek (INTINT, 0) + 2 * sizeof (int);
    seg = peek (INTINT + sizeof (int), 0);
    pokew (offset, seg, gfilhand);
    offset += sizeof (int);
    pokew (offset, seg, gretcode);
    offset += sizeof (int);
    pokew (offset, seg, NULL);      /* poke NULL data pointer */
    break;
case 3 :            /* file close */
case 4 :            /* insert key */
    offset = peek (INTINT, 0) + 2 * sizeof (int);
    seg = peek (INTINT + sizeof (int), 0);
    pokew (offset, seg, NULL);      /* NULL file handle */
    offset += sizeof (int);
    pokew (offset, seg, gretcode);  /* send return code */
    offset += sizeof (int);
    pokew (offset, seg, NULL);      /* NULL data pointer */
    break;
case 5 :            /* random read */
    offset = peek (INTINT, 0) +2 * sizeof (int);
    seg = peek (INTINT + sizeof (int), 0);
    pokew (offset, seg, NULL);      /* NULL file handle */
    offset += sizeof (int);
    pokew (offset, seg, gretcode);
    offset += sizeof (int);
    pokew (offset, seg, gdatapt);   /* return data pointer */
    break;

default:
    break;
}  /* end of switch */
}  /* end of btexport */
```

LISTING 10: btclose.c

```
/* btclose */
#include <stdio.h>
#include <btextern.h>
int btclose (filhand)

unsigned filhand;

/* close a file and free buffers */
{
    char *cp;
    int i;

/* make sure file is open */
    if (btfilar[filhand].handle == NULL)
    BTSETCOD (filhand, NULL, 61);   /* file not open */

/* write index info record it may have changed     */

/* move new root value to info index record before close */

    *(btfilar[filhand].infobuf) = btfilar[filhand].root;
    movmem (btfilar[filhand].infobuf,
    btfilar[filhand].filbuf, LBLEN);
    if ((i = btwrit (filhand, 0)))
    BTSETCOD (filhand, 0, i);

/* free index info buffer */
    cp = (char *)btfilar[ filhand].infobuf;
    free (cp);

/* free root record buffer */
    cp = (char *)btfilar[ filhand].filbuf;
    free (cp);
/* free control block      */
    btfilar[filhand].handle = NULL;

/* close file      */
    fclose (btfilar[ filhand].fdesc);
    return (0);
}
/* end of btclose */
```


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LISTING 11: btopen.c

```
/* btopen          */
#include <stdio.h>
#include <btextern.h>

int btopen (gfilnam)
char gfilnam[];


/* open an existing index file     */
{
   int i, *ip,occurs;
   char *cp;

    if ((fp = fopen (gfilnam, "rwb")) == NULL)
   BTSETCOD (NULL, NULL, 4);       /* set file open error */
    if ((openkt = btopnkt () ) == -1)
   BTSETCOD (NULL, NULL, 63);      /* set max files open */
    if (!(btfilar[openkt].infobuf =
   (int *)calloc (LBLEN, sizeof (char))))
   BTSETCOD (openkt, NULL, 7);     /* no memory */
    if (!(btfilar[openkt].filbuf =
   (int *)calloc (LBLEN ,sizeof (char))))
   BTSETCOD (openkt, NULL, 7);     /* no memory */

/* now read index info record = # zero     */
    btfilar[openkt].fdesc = fp;
    if ((i = btread (openkt, 0)))
   BTSETCOD (openkt, 0, i);        /* bad read */
    movmem (btfilar[openkt].filbuf, btfilar[openkt].infobuf,LBLEN);

/* initialize file control block   */
    ip = btfilar[openkt].infobuf;  /* initialize pointer */
    btfilar[openkt].handle = openkt;
    strcpy (btfilar[openkt].curkey,"                ");
    occurs = (LBLEN - 1) / (gkeylen + 3);
    btfilar[openkt].ikeyptr =
   (char *)(btfilar[openkt].filbuf + occurs);
    btfilar[openkt].root = *ip++;  /* 1 st integer */
    btfilar[openkt].keylen = *ip;  /* 2 nd integer */
    strcpy (btfilar[openkt].filnam, gfilnam);  /* copy file name */
    btfilar[openkt].fdesc = fp;

/* now read root record into filbuf */
    if ((i = btread (openkt, btfilar[openkt].root)))
   BTSETCOD (openkt, btfilar[openkt].root, i); /* bad read */

/* give value of openkt to the world */
    gfilhand = openkt;
    return (0);
}
/* end of btopen           */
```

LISTING 12: btsys.c

```
/* btsys           */
#include <stdio.h>
#include <btextern.h>
int btsys ()

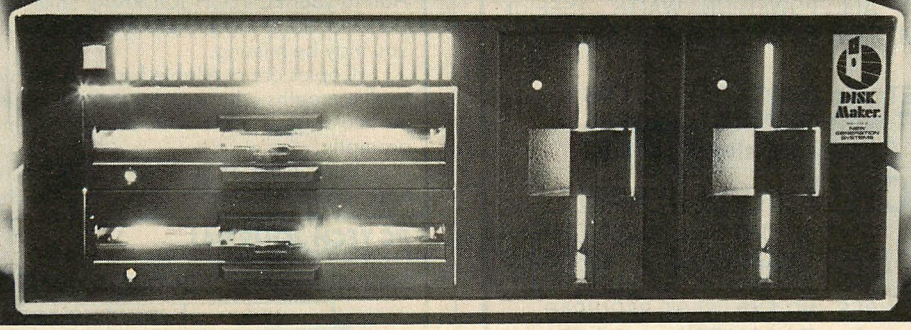
/* this is the btree system function       */
{
btparm ();
switch (gfcode)    {
case 0 : break;            /* bad function code */
case 1 :           /* file create  */
   gretcode = btcreat (gfilnam);
   break;
case 2 :           /* file open    */
   gretcode = btopen (gfilnam);
   break;
case 3 :           /* file close   */
   gretcode = btclose (gfilhand);
   break;
case 4 :           /* insert key */
   gretcode = btisrt (gfilhand, gfilkey, gdatapt);
   break;
case 5:            /* random read */
   gretcode = btired (gfilhand, gfilkey);
   break;
}  /* end of switch        */
btexport ();

}  /* end of btsys         */
```


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LISTING 13: btplace.c

```
/* btplace          */
#include <stdio.h>
#include <btextern.h>
int btplace (filhand, key)
int filhand;
char *key;

{
   int i,j,k,occurs,node,klength;
   char *cp;

/* clear stack              */
clear ();

/* initialize keylength     */
klength = btfilar[filhand].keylen;
occurs = (LBLEN - 1) / (klength + 3);
node = btfilar[filhand].root;
cp = (char *)btfilar[filhand].filbuf + (LBLEN - 1);

do {
   ip1 = btfilar[filhand].filbuf;
   cp1 = btfilar[filhand].ikeyptr;
   j = 0;
   if ((i = btread (filhand, node)))
         BTSETCOD (filhand, node, i);
   while ((i = strcmp (cp1, "")) != 0
         && (k = strcmp (cp1, key)) == -1)
         {
         j++;
         cp1 += (klength + 1);
         };
   push (node);
   push (j);
   node = ip1[j];
} while ((node != NULL) && (*cp != 'Y'));
return (0);
}  /* end of btplace        */
```

LISTING 14: btired.c

```
/* btired           */
#include <stdio.h>
#include <btextern.h>
int btired (filhand, key)
int filhand;
char key[];

/* random read function     */

{
    int i, j, k, occurs, klength, recno;
    char *cp;

printf("BTIRED filhand %d key %s\n", filhand, key);

klength = btfilar[filhand].keylen; /* get key length */
occurs = (LBLEN - 1) / (klength + 3);
recno = btfilar[filhand].root;

/* get root record */
if ((i = btread (filhand, recno)))
   BTSETCOD (filhand, recno, i);   /* set read error */

/* start looping forever    */
while (1)  {
    if (*((char *)btfilar[filhand].filbuf + (LBLEN -1)) == 'N') {
    ip1 = btfilar[filhand].filbuf;
    cp1 = (char *)(btfilar[filhand].filbuf + occurs);

    while ((i = strcmp (cp1, "")) != 0
   && (k = strcmp (cp1, key)) == -1)
   {
   ip1++;
   cp1 += (klength + 1);
   }
    recno = *ip1;
    if ((i = btread (filhand, recno)))
   BTSETCOD (filhand, recno, i);   /* set read error */
    }
```


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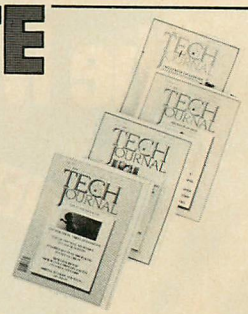
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```
    else    {
    j = 0;
    ip1 = btfilar[filhand].filbuf;
    cp1 = btfilar[filhand].ikeyptr;
    while (*ip1 != NULL)    {
    if ((i = strcmp (cp1, key)) == 0)       {
       gdatapt = *ip1;
       return (0);

        }
    else    {

            ip1++;
            cp1 += (klength + 1);
    };      /* end else */
    };
    return (-1);
    };      /* end else */
 }  /* end while */
 }  /* end btired */
```

LISTING 15: btisrt.c

```
/*    btisrt                */
#include <stdio.h>
#include <btextern.h>

int btisrt (filhand, key, datapt)
int filhand, datapt;
char key[];

/* main routine to insert key into btree   */
{
   int i,j,k,node,holdptr,*ip,klength,occurs;
   char *cp,leaf;

   int *new,*temp,last;

/* find place to insert the key            */
if ((i = btplace (filhand, key)))
   BTSETCOD (filhand, NULL, 60);   /* set logic error */
```

```
/* this value is already stored in the stack by btplace */
klength = btfilar[filhand].keylen;
occurs = (LBLEN - 1) / (btfilar[filhand].keylen + 3);
j = pop ();
node = pop ();
leaf = 'Y';

again:

ip = btfilar[filhand].filbuf + (occurs - 1);
holdptr = *ip;

/* set up pointers to move keys over by one position */
ip2 = btfilar[filhand].filbuf + (occurs - 1);      /* start of move */
ip1 = ip2 - 1;      /* from where to move */
ip3 = btfilar[filhand].filbuf + j; /* till when to move */
while (ip1 >= ip3) {
   *ip2-- = *ip1--;
}
/* now move keys */
cp2 = (char *)(btfilar[filhand].filbuf + occurs);
cp2 += (occurs - 1)*(klength + 1); /* where to move */
cp1 = cp2 - (klength + 1);
cp3 = (char *)(btfilar[filhand].filbuf + occurs);
cp3 += j*(klength + 1);

while (cp1 >= cp3) {
   strcpy (cp2,cp1);
   cp1 -= (klength + 1);
   cp2 -= (klength + 1);
}

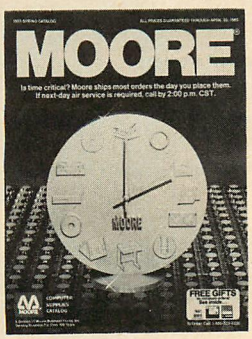
strcpy (cp2,key);
*ip2 = datapt;              /* insert new key and pointer */

cp = (char *)btfilar[filhand].filbuf;
cp += (LBLEN - 1);
*cp = leaf;

cp = (char *)(btfilar[filhand].filbuf + occurs);
cp += (occurs - 1)*(klength + 1);

if ((i = strcmp (cp, "")) == 0)    {
```


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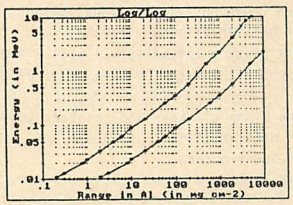
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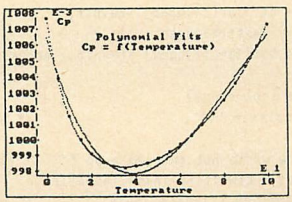
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```
    if ((i = btwrit (filhand, node)))
            BTSETCOD (filhand, node, i);  /* set write error */
    return (0);
}

    /*      btdivd          */
/* divides a node gets space and writes it out      */

else            {

if (!( new = (int*)calloc (LBLEN, (sizeof (char)))))
    BTSETCOD (NULL, NULL, 7);       /* no core */

if (!(temp = (int*)calloc (LBLEN, sizeof (char))))
    BTSETCOD (NULL, NULL, 7);       /* no core */

last = occurs / 2;
k = 0;

cp1 = btfilar[filhand].ikeyptr;
cp1 += last*(klength + 1); /* start of key move */
cp3 = btfilar[filhand].ikeyptr + occurs*(klength + 1);
cp2 = (char*)(new + occurs);        /* init destination */
 while (cp1 < cp3)
    *cp2++ = *cp1++;        /* move keys */

ip1 = btfilar[filhand].filbuf;      /* start of pointer area */
ip3 = ip1 + occurs;         /* end of pointers */
ip1 += last;
ip2 = new;                  /* init destination */

while (ip1 < ip3)
    *ip2++ = *ip1++;        /* move pointers */

*ip2 = holdptr;

while (++ip2 < (new + occurs))
    *ip2 = NULL;            /* zero all pointers */
cp3 = (char *)new + LBLEN; /* end of keys */

while (cp2 < cp3)
    *cp2++ = '\0';
/* all keys have now been nulled */

/* set true flag    */
*((char *)(new) + (LBLEN -1)) = leaf;       /* keep old flag value */
/* move to temporary area */
movmem (btfilar[filhand].filbuf, temp, LBLEN);
movmem (new,btfilar[filhand].filbuf, LBLEN);

/* write new node */
if ((i = btwrit (filhand, (k = btgetsp (filhand)))))
    BTSETCOD (filhand, k, i);       /* set error */
movmem (temp, btfilar[filhand].filbuf, LBLEN);
cp1 = btfilar[filhand].ikeyptr;
cp1 += (last - 1)*(klength + 1);   /* init pointers */
strcpy (key, cp1);                  /* store key */

/* now blank all keys and pointers that were moved */
ip1 = btfilar[filhand].filbuf;
ip3 = ip1 + occurs;
ip1 += last;

while (ip1 < ip3)
    *ip1++ = NULL;                  /* zero all pointers */

cp1 = btfilar[filhand].ikeyptr;
cp1 += last*(klength + 1);
cp3 = btfilar[filhand].ikeyptr + occurs*(klength + 1);

while (cp1 < cp3)
    *cp1++ = '\0';                  /* null all keys */

/* now write out changed node */
if ((i = btwrit (filhand, node)))
    BTSETCOD (filhand, node, i);    /* set write error */

/* free buffers */
free (temp);
free (new);

}  /* end if        */

/* check if root node has been split */
datapt = node;          /* save node value before popping stack */
j = pop ();
if ((node = pop ()) != NULL)        {
    if ((i = btread (filhand, node)))
            BTSETCOD (filhand, node,i);
    ip = btfilar[filhand].filbuf + j;
    *ip = k;
    cp = (char *)btfilar[filhand].filbuf;
    cp += (LBLEN - 1);
    leaf = 'N';
    goto again;
}

else        {
    ip = btfilar[filhand].filbuf;
    *ip++ = datapt;
    *ip = k;                /* value of new node in root */

    cp = btfilar[filhand].ikeyptr;
    strcpy (cp, key);
    cp += (klength + 1);
    strcpy (cp,'\0');

/* now clear out rest of new root */
    ip1 = btfilar[filhand].filbuf + 2;      /* starting place */
    ip3 = btfilar[filhand].filbuf + occurs;/* ending place */
    while (ip1 < ip3)
            *ip1++ = NULL;          /* null it baby ! */
    cp1 = (char *)(btfilar[filhand].filbuf + occurs);
    cp3 = cp1 + occurs*(klength + 1); /* end here */
    cp1 += (klength + 1);
    while (cp1 < cp3)
            *cp1++ = '\0';          /* null keys */

    *((char *)(btfilar[filhand].filbuf) + (LBLEN -1)) = 'N';

/* write out new root       */
    k = btgetsp (filhand);  /* get a new node for new root */
    if ((i = btwrit (filhand, k)))
            BTSETCOD (filhand, k, i);    /* set error code */

/* put new root value in control block */
    btfilar[filhand].root = k;
}  /* end if */

return (0);
}  /* end btisrt */
```

LISTING 16: btacslib.c

```
/* btsys access library */
#include <stdio.h>
#define INTCHAR 388
#define INTINT  392
#define INTKEY  396

    static unsigned       seg, offset;
    static int *word,i;
    static int parm [] = { 0, 0 , 0, 0, 0 };
    static char filnam[] = "              ";
    static char filkey[]   = "                  ";

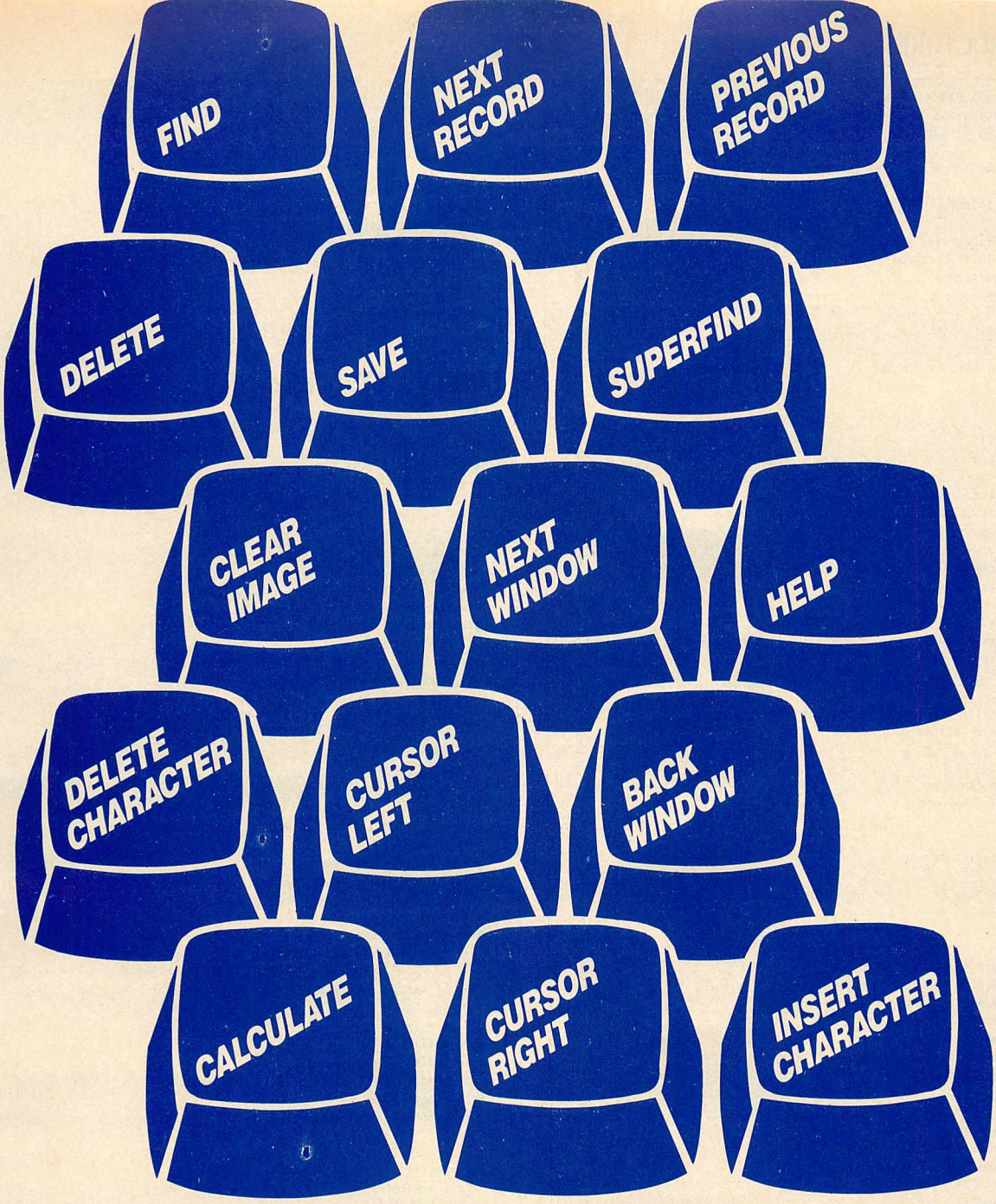
        static struct { int cs,ss,ds,es;} segreg,*segregp;

    static int fromoff,fromseg,*tooff,toseg;
    extern struct {
                    unsigned fcode;
                    unsigned keylen;
                    unsigned filhand;
                    unsigned datapt;
                    char    filkey[17];
                    char    filnam[15];
                  } btstruct, *structp;

    /*      and it begins !!!!!!    */
static int btinit ()
{
    segread(&segreg);
    /*      set up int decimal INTINT */
    seg = 0;
    offset = INTINT;
    word = parm;
    pokew (offset, seg, word);

    offset = INTINT + sizeof (int);
    word = segreg.ds;
    pokew (offset, seg, word);

    /*      set up int decimal INTCHAR */
    seg = 0;
    offset = INTCHAR;
    word = filnam;
    pokew (offset, seg, word);
```



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```
    offset = INTCHAR + sizeof (int);
    word = segreg.ds;
    pokew (offset, seg, word);

    /*      set up int decimal INTKEY */
    seg = 0;
    offset = INTKEY;
    word = filkey;
    pokew (offset, seg, word);
    offset = INTKEY + sizeof (int);
    word = segreg.ds;
    pokew (offset, seg, word);

}   /* end btinit   */

    /*      do btsys interrupt      */

static int btintr ()
{
    int times;
    struct regval {
            int ax, bx, cx, dx, si, di, ds, es;}
            *xxv, yyv;
    struct {int cs, ss, xds, xes;} *rrv,ssv;
    rrv = &ssv;

    segread (rrv);
    yyv.ds = rrv->xds;
    yyv.es = rrv->xes;
    xxv = &yyv;
            sysint (0x60, xxv, xxv);        /* execute the interrupt */
}   /* end btintr   */

/* btfunc                   */
/* performs interface functions between user programs
   and the btree system
*/

int btfunc (structp)
struct btstruct *structp;

{
    switch (structp->fcode) {

    case 0 : btinit ();     /* initialize address for interrupts */
            break;
    case 1:                 /* file create */
    case 2:                 /* file open */
            parm[0] = structp->fcode;
            parm[1] = structp->keylen;
            parm[2] = NULL;
            parm[3] = NULL;
            parm[4] = NULL;
            strcpy (filnam, structp->filnam);
            strcpy (filkey, "");
            break;
    case 3 :                /* file close */
            parm[0] = structp->fcode;
            parm[1] = NULL;
            parm[2] = structp->filhand;
            parm[3] = NULL;
            parm[4] = NULL;
            strcpy (filnam, "");
            strcpy (filkey, "");
            break;

    case 4 :                /* key insert */
            parm[0] = structp->fcode;
            parm[1] = NULL;
            parm[2] = structp->filhand;
            parm[3] = NULL;
            parm[4] = structp->datapt;
            strcpy (filnam, "");
            strcpy (filkey, structp->filkey);
            break;
    case 5 :                /* random read */
            parm[0] = structp->fcode;
            parm[1] = NULL;
            parm[2] = structp->filhand;
            parm[3] = NULL;
            parm[4] = NULL;
            strcpy (filnam,"");
            strcpy (filkey, structp->filkey);
            break;

    default :               /* bad function code */
            return (10);
            break;
    }       /* end switch */

/* now perform the btsys interrupt */
    btintr ();

/* set return values for user program */
    structp->fcode = parm[0];
    structp->filhand = parm[2];
    structp->datapt = parm[4];
    return (parm[3]);

}   /* end of btfunc        */
    /*      THE END         */
```

LISTING 17: bttest.c

```
/* test vehicle    */

#include <stdio.h>
#include <btglobal.h>
#include "b:btintr.c"
main ()

{
    unsigned        seg, offset;
    int *word,i,a,b;
    static int int41[] = { 1, 3 , 1, 0, 10};
    static char filnam[] = "b:testfile.idx";
    static char filkey[17];

    struct { int cs,ss,ds,es;} segreg,*segregp;
    int fromoff,fromseg,*tooff,toseg;

    /*      and it begins !!!!!!    */

    segread (&segreg);

    /*      set up int 0x41 */
    seg = 0;
    offset = INTINT;
    word = int41;
    pokew (offset, seg, word);
    printf ("value offset %x  %x \n", offset, word);
    offset = INTINT + sizeof (int);
    word = segreg.ds;
    pokew (offset, seg, word);
    printf ("value seg %x  %x \n", offset, word);

    /*      set up int 0x42 */
    seg = 0;
    offset = INTCHAR;
    word = filnam;
    pokew (offset, seg, word);
    offset = INTCHAR + sizeof (int);
    word = segreg.ds;
    pokew (offset, seg, word);

    /*      set up int 0x43 */
    seg = 0;
    offset = INTKEY;
    word = filkey;
    pokew (offset, seg, word);
    offset = INTKEY + sizeof (int);
    word = segreg.ds;
    pokew (offset, seg, word);

Printf (" enter start and end values\n");
scanf ("%d %d",&a,&b);

int41[0] = 1;
int41[1] = 3;
btintr ();
for (i = a  ;i <  b  ;i++) {
   itoa (i, filkey);
   int41[4] = b - i;
   int41[0] = 4;
   int41[2] = 1;

   btintr ();
}

for (i = a  ;i <  b  ; i++){
   int41[2] = 1;
   itoa (i, filkey);
   int41[0] = 5;
   btintr ();
```

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```
    printf ("IN BTTEST datapt is %d  key is %s\n",
            int41[4], filkey);
}
int41[2] = 1;
int41[0] = 3;
btintr ();

}
```

LISTING 18: btuse.c

```
/*    sample user program to test btsys     */

   struct {
            unsigned fcode;
            unsigned keylen;
            unsigned filhand;
            unsigned datapt;
            char     filkey[17];
            char     filnam[15];
            }        btstruct, *structp = &btstruct;

main ()

{
   int      code, number;
   char     literal[17];
   int      retcode;

do {
   printf ("enter function code\n");
   scanf ("%d", &code);
   switch (code)   {

   case 0 :         /* initialize system    */
            structp->fcode = code;
            retcode = btfunc (structp);
            break;
   case 1 :         /* file create */
   case 2 :         /* file open */
            printf ("enter file name\n");
            scanf ("%s", literal);
            strcpy (structp->filnam, literal);
            printf ("enter keylength\n");
            scanf ("%d", &number);
            structp->keylen = number;
            structp->fcode = code;
            retcode = btfunc (structp);
            printf ("retcode %d filhand %d\n",
                    retcode, structp->filhand);
            break;
   case 3 :         /* file close */
            printf ("enter file handle\n");
            scanf ("%d", &number);
            structp->filhand = number;
            structp->fcode = code;
            retcode = btfunc (structp);
            printf ("retcode %d from close\n", retcode);
            break;
   case 4 :         /* insert keys */
            printf ("enter file handle\n");
            scanf ("%d", &number);
            structp->filhand = number;
            printf ("enter key\n");
            scanf ("%s", literal);
            strcpy (structp->filkey, literal);
            printf ("enter data pointer\n");
            scanf ("%d", &number);
            structp->datapt = number;
            structp->fcode = code;
            retcode = btfunc (structp);
            printf ("retcode %d from insert\n", retcode);
            break;
   case 5 :         /* random read */
            printf ("enter file handle\n");
            scanf ("%d", &number);
            structp->filhand = number;
            printf ("enter key\n");
            scanf ("%s", literal);
            strcpy (structp->filkey, literal);
            structp->fcode = code;
            retcode = btfunc (structp);
            printf ("retcode %d key %s datapt %d\n",
                    retcode, structp->filkey, structp->datapt);
            break;
   default : break;
   }        /* end switch */
} while (code != -1);/* end while */

}  /* end btuse */
```

LISTING 19: btsetup.c

```
/* btree system program     */
#include <stdio.h>
#include <btglobal.h>

btsys ();

main ()
   /*       sets up shop     */
{

/* this is executed only to setup residence in m/c */

/* initialize control block         */
   int i;
for (i = 1; i<= MAXFIL; ++i)
   btfilar[i].handle = NULL;
   intrinit (btsys, STACKS, VECNO);
   bdos (SETUP, PARAS);

}
```


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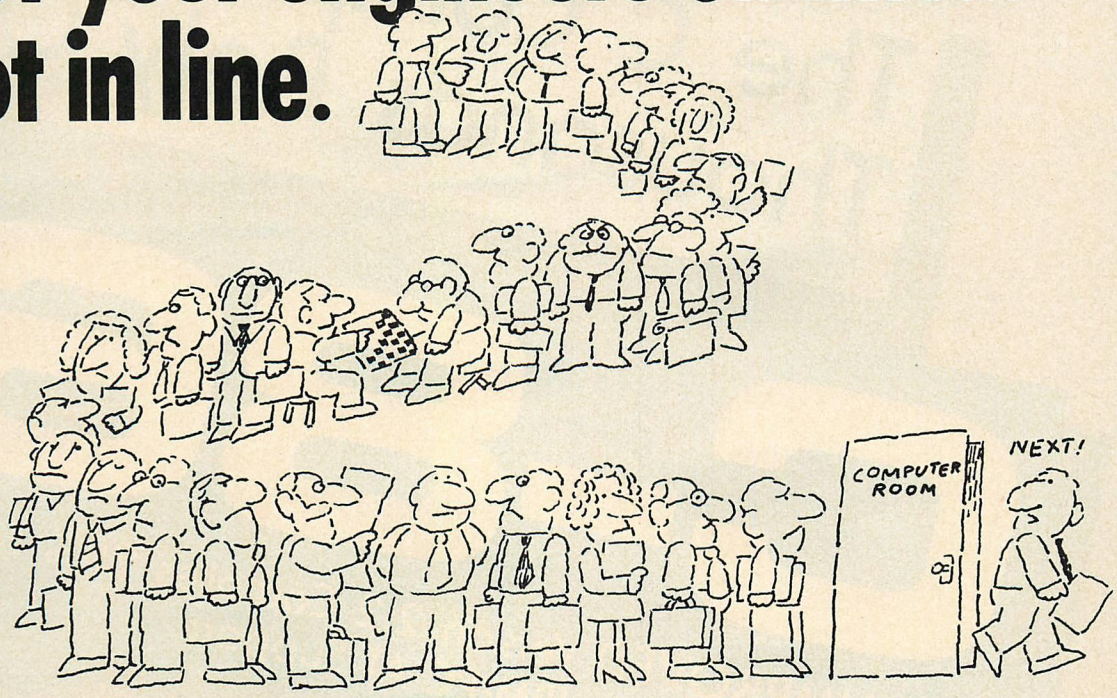
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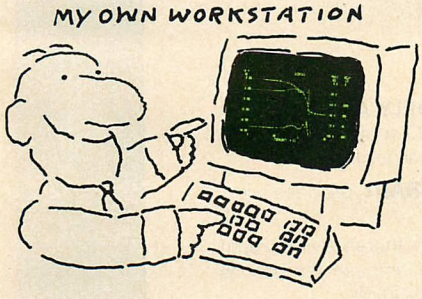
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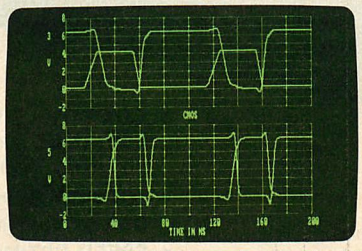
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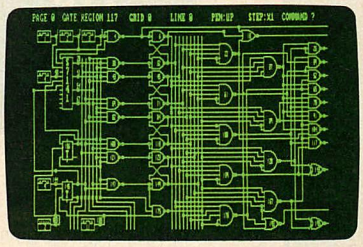
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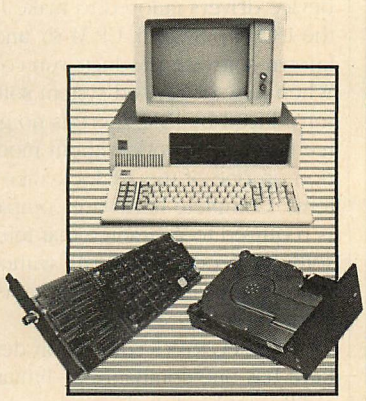
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The Making of an XT

The upwardly mobile PC reaches XT status with this do-it-yourself conversion procedure.

AUGIE HANSEN

Judging by the large number of fixed-disk conversion systems available for the IBM PC, many PC owners must want to upgrade to the level of the PC/XT. At least the manufacturers think so. Estimates of the number of original PCs (with 64KB motherboards—sometimes called the PC-1) vary widely, and IBM won't tell. A good estimate is 300,000 to 400,000. An even greater number of the newer 256KB systems have been put into service. If only a small percentage of all these PCs were upgraded with mass storage subsystems, that's still a lot of fixed disks.

The reasons for upgrading the faithful but now inadequate IBM PC to an XT are few and simple. First, PC/IX (IBM's version of UNIX) requires an XT as its host. Something close is not good enough. Second, some PC-DOS development environments, such as Computer Innovations CI-C86 C compiler, require more disk capacity and faster access; they just don't fit conveniently on one double-sided floppy disk, and they do a lot of reading and writing of disk files while operating.

PC users who wish to move up to an XT face many problems, both technical and economic. There are several ways to achieve the desired result:

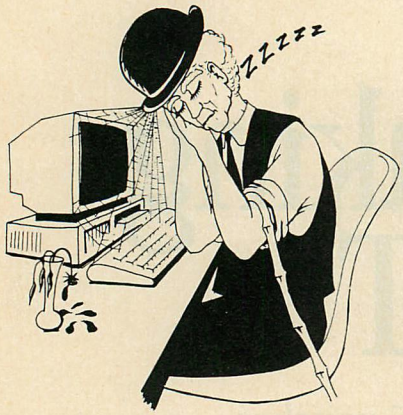
- Sell the original PC and buy an XT. Unfortunately, the difference in price is considerable. Since the cost of a new XT with only 128KB is $4,275, it's easy to take a financial beating using this approach.
- Buy an internal or external non-IBM fixed-disk expansion system. (Ten different fixed-disk drives are described in "Ten by Ten," Thomas V. Hoffmann, November 1984, p. 52). Prices for an upgrade of this type range from $976 to $2,250. Is it completely XT-compatible? Probably not, although a few fixed-disk subsystems come close enough to run PC-DOS without using special device drivers.
- Buy an IBM fixed-disk expansion unit. This is also an expensive option ($2,880), and a place must be found in the office for the additional outboard hardware.
- Buy the individual components and do the conversion described in this article. This can be done for $1,000 to $1,500, so it saves money and real estate on the desktop, too.

Anyone who breaks out in a cold sweat and gets rubbery legs at the thought of ripping off the cover and peering inside an expensive computer is advised to seek professional help—the kind that knows something about electronics—or to take an easier but more expensive way out. Although this conversion project involves nothing more tricky than replacing a few components and hooking up some wires, there are several opportunities to put something in backwards, possibly producing a system that fails to operate, or worse, damaging some expensive components. Warranties on recently purchased PCs and service contracts will be nullified by this modification, so check terms and conditions before beginning.

Of the expansion units I tried before becoming my own system integrator, none was completely XT-compatible. The Apparat fixed-disk system came closest but fell short on its inability to run some operating systems, such as

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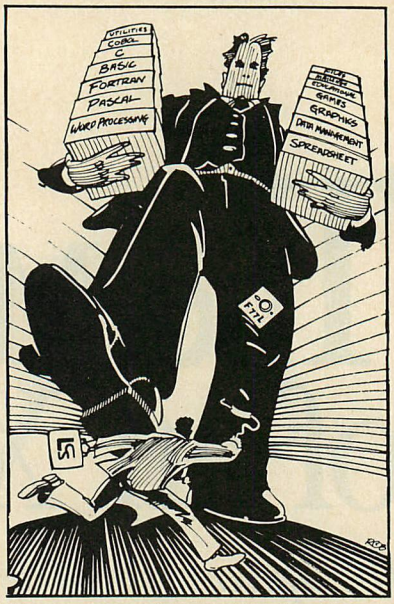
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XT CONVERSION

PC/IX and VENIX/86. In its favor, however, Apparat claims only that it is PC-DOS 2.0 compatible, nothing more.

Fixed-disk system designers typically use an existing controller card and custom-designed firmware or software device drivers tailored to make PC-DOS, the UCSD p-System, CP/M-86, and other known software products run correctly. When new or revised system software is introduced by IBM, there is no guarantee that it will work without modification on one of the XT look-alike systems. Complete hardware compatibility is required to guarantee that future IBM software products will run without requiring any changes to hardware, firmware, or software drivers.

The PC-to-XT conversion described here has one compatibility limitation of a different kind. It does not increase the number of available expansion slots. If more slots are needed, the removed 63.5-watt power supply may be used with a bare-bones expansion chassis, or an I-Bus expansion unit may be added. It's still less expensive than buying an XT or an IBM expansion chassis, although collecting and installing the components requires more work.

BITS AND PIECES

The PC-to-XT conversion calls for four major components, which can be obtained from various sources. In addition to a fixed disk and controller card (with cables), the conversion requires a beefed-up power supply and a new ROM BIOS integrated circuit. See table 1 for a list of component suppliers.

With regard to the controller card (*fixed-disk adapter* in IBM's parlance), there is only one way to go to assure full XT compatibility—directly to the nearest IBM dealer or Product Center. The IBM adapter is an off-the-shelf item. The package includes installation instructions for the expansion chassis because that's where IBM thinks the adapter will be installed.

Both Xebec and Adaptec have announced fixed-disk adapters that are operationally close to the IBM adapter. The new Xebec 1210 fixed-disk adapter works with PC/IX, as well as with VENIX/86 and XENIX (UNIX implementations for the XT), which I had trouble running with Western Digital and Data Technology Corporation controllers. (Since this article was written, DTC has modified its controller to work with PC/IX.) Another new Xebec product, the model 1220 adapter, provides an additional benefit: it controls both fixed disks and floppy disks while consuming only one slot. The Xebec adapters probably have firmware that has been ad-

TABLE 1: *Component Sources*

FIXED-DISK DRIVE ADAPTER

*IBM Fixed-disk Drive Adapter: $590
IBM Product Centers
(also available from authorized IBM dealers)

Adaptec: $310
580 Cottonwood Drive
Milpitas, CA 95035
408/946-8600

Xebec
1210 fixed-disk adapter: $245
1220 fixed/floppy disk adapter: $295
3579 Highway 50 East
Carson City, NV 89701
800/982-3232

ROM BIOS UPGRADE

*IBM ROM BIOS Upgrade Kit: $30
IBM Product Centers
(also available from authorized IBM dealers)

10MB FIXED DISK

*Miniscribe 2012: $499
Miniscribe drive, Xebec controller, and 140-watt power supply: $949
Apparat
4401 S. Tamarac Parkway
Denver, CO 80237
303/741-1778

Seagate: $515
920 Disc Drive
Scotts Valley, CA 95066
408/438-6550

Cogito: $539
The Great Salt Lake Computer Company
1780 W. 2300 South
Salt Lake City, UT 84119
800/545-2633

Shugart drive: $429
Shugart drive and Xebec controller: $629
PCs Limited
7801 N. Lamar, #E-200
Austin, TX 78752
800/IBM-5150

(plus many other retailers and industrial distributors)

INTERNAL POWER SUPPLY

ISPS 140-watt: $295
Micro Design International, Inc.
6566 University Blvd.
Winter Park, FL 32792
305/677-8333

130-watt: $169
FORTRON
3797 Yale Way
Fremont, CA 94539
800/821-9771

130-watt: $199
Apparat
4401 South Tamarac Parkway
Denver, CO 80237
303/741-1778

IBM PC/XT 130-watt
(usually available from most authorized IBM PC dealers, about $215)

The components needed to upgrade a PC to an XT can be obtained from a variety of sources. Those that were used to build the author's system are identified with an asterisk.

justed to handle PC/IX, but that could fail with future IBM software, so it cannot be said to be completely hardware-compatible with IBM's adapter.

The Adaptec fixed-disk adapter works with VENIX/86 and XENIX, but not with PC/IX, so it is not 100-percent hardware-compatible with the IBM adapter. The Xebec and Adaptec fixed-disk adapters may be acceptable for most circumstances, but IBM could probably take advantage of whatever incompatibilities exist when designing future software products in order to prevent operation on foreign hardware.

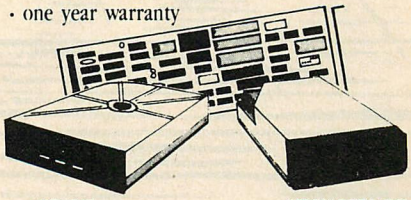
One item needed to make the original PC system (with a maximum of 64KB RAM on the motherboard) look for a fixed disk when the system is booted is the ROM BIOS upgrade kit. The newer system units with the 256KB motherboard have the updated ROM BIOS already installed. The BIOS function that finds the fixed-disk system, if one is present, is called ROM scan. During the power-on self test (POST), the new BIOS automatically searches for ROM on the adapters installed in the I/O channel. Once the default vectors are set up, any system-accessible ROM that is found may take control or attach itself to the system code by establishing new interrupts or intercepting default interrupts. The ROM BIOS upgrade kits are available only from IBM Product Centers and dealers.

The product may prove difficult to obtain. Two IBM Product Centers in Denver took more than four months to find one for me.

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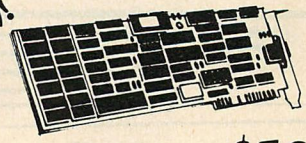
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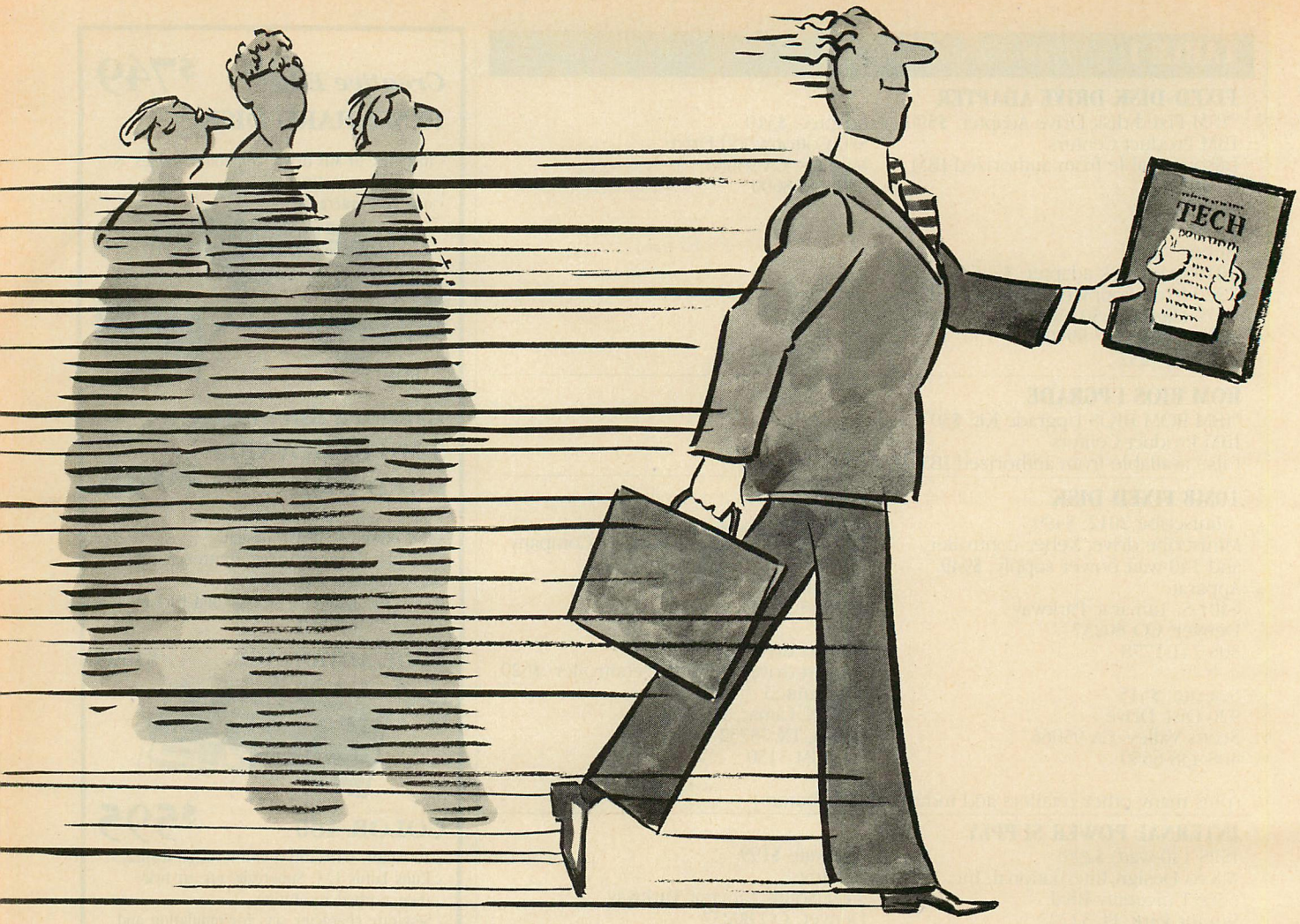
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TABLE 2: *Fixed Disk Specifications*

OPERATIONAL	
Tracks	1,224 (306 cylinders x 4 heads)
Track Density	345 tracks per inch
Access Time	3 ms track-to-track
Average Latency	8.33 ms
Error Rates:	
Soft Read Errors	1 per 1,010 bits read
Hard Read Errors	1 per 1,012 bits read
Seek Errors	1 per 106 seeks
Transfer Rate	5.0 Mbps
Recording Mode	MFM
PHYSICAL AND ENVIRONMENTAL	
DESIGN LIFE	5 years (8,000 hours MTF)
DIMENSIONS:	
Height	3.25 inches (82.55 mm)
Width	5.75 inches (146.05 mm)
Depth	8.0 inches (203.2 mm)
TEMPERATURE:	
Operating	40F to 122F (4C to 50C) degrees
Nonoperating	−40F to 140F (−40C to 60C) degrees
HUMIDITY:	
Operating	8% to 80% (noncondensing)
Max Wet Bulb	78F (26C) degrees
POWER:	+12 Vdc +/− 5% @ 1.8 A (4.5 A max)
	+5 Vdc +/− 5% @ 0.7 A (1.0 max)
Ripple	1% max into equiv. resistive load

The 10MB fixed disk for the upgrade should be compatible with IBM's fixed disk in operational and physical specifications, and it must conform to the ST-412/506 interface.

On the other hand, there is currently a glut of 10MB drives. They can be purchased at many retail stores and by mail order. It is worthwhile to shop around for the best possible price and delivery. The price difference could be $800 or more. Although IBM may be more expensive, it does provide a detailed installation booklet along with its disk. Most other suppliers of bare disks provide little or no supporting information. IBM also provides the machine screws that are needed to secure the disk to the PC chassis.

IBM's fixed-disk specifications are summarized in table 2. The drive must conform to the industry standard ST-412/506 disk interface, which describes the physical characteristics of the interconnection. IBM formats the disk into 512-byte sectors, 17 per track for 68 sectors per cylinder. 1,224 such tracks yield 10,653,696 bytes of formatted storage. Available data storage is that amount minus boot record, file allocation, and directory storage amounts, and minus any bad clusters found by format commands.

The MiniScribe 10MB disk, which I bought from Apparat, is reliable and of high quality. Many of the 10MB disks sold by IBM are manufactured by MiniScribe. Seagate Technology also provides disks for the XT. IBM has brought other disk suppliers into the fold in order to avoid becoming too dependent on just a few suppliers.

Choosing a reputable supplier who will repair or replace a defective or failed disk is important. The supplier should "park" the heads off the working area of the disk platters before shipping it to prevent damage to the heads and the disk surfaces. Manufacturers of drives that use plated storage surfaces claim this is unnecessary, but it is an inexpensive and simple precaution. No more than a few clusters should be marked as bad. The two MiniScribe drives I purchased, one new and one refurbished, had no bad sectors on delivery and are still free of defects after months of mostly full-time operation.

The fixed disk and its controller consume much power and return quite a bit of it to the system unit in the form of heat. A 130-watt internal power supply is needed. It must meet certain minimum specifications (see figure 1) and must be a close physical replacement for the 63.5-watt unit in the PC. A higher-speed fan is required to exhaust the extra heat that is produced.

A replacement power supply must not be any larger than the A and C dimensions shown in figure 1; if a flush-mounted power switch is used, however, dimension B may be stretched a few inches. The power supply case may extend completely to the cabinet shell

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at the right side of the computer, allowing clearance for the cover to slide off without interference. The left side of the power supply case may also be extended about two inches to the left if a two-inch overhang is provided to clear the motherboard and to permit access to the power connectors along its edge.

A fixed disk starting to spin its disk platter assembly is similar to a person riding a bicycle from a standing start. A great deal of energy is expended initially to begin the movement. Once motion is established, the effort required to maintain it is significantly less.

A measure of this start-up effort for the disk is the amount of current drawn from the power supply. The +12-volt supply powers the disk motor. Initially, the PC's disk motor may draw four or more amperes, settling down to a little under two amps at steady state (3600 RPM), as shown in figure 2. The starting current is limited by the resistance of the wires winding in the motor and usually by external means in the disk speed-control circuitry and by the internal resistance of the power supply itself. At low rotation speeds, very little counter emf (electromotive force) is produced by the coils of wire moving in magnetic fields. As motor speed increases so does the counter emf that opposes the supplied current flow. Eventually, a balance is struck between the source voltage and the counter emf, resulting in an armature current flow that is sufficent to drive the load and to compensate for friction and normal dissipation (resistive losses).

In fixed-disk drives, the initial surge is limited to about 4.5 amps. For a few seconds after the power is turned on, the disk motor is trying to take nearly all of the available power from a 63.5-watt supply, leaving little for the disk electronics or for any other components in the system. If the combined load of all disk drives and adapter cards is large, the result is a pronounced sag in the output voltages of the supply. The supply protects itself and other components by shutting down if voltage levels stray outside specified sense levels (see figure 1). The 130-watt supply has a greater surge capacity and a higher full-load rating than its smaller sibling, so it can handle the disk and many adapter cards simultaneously.

The fixed disk and its controller consume much power and return much of it to the system unit as heat.

The power supply unit I purchased is distributed by Micro Design International. It has held up well under a heavy load for four months of nearly continuous use and it keeps the PC and its contents cool. The MDI power supply is larger than the PC's 63.5-watt unit, but it fits into the available space. It is solidly designed and dependable, but at $295 it is not inexpensive.

My system has two Teac half-height floppy drives where the original A: drive was installed and a cadre of heat-producing circuit cards (both monochrome and color adapters, the Apparat CRAMBO with 512KB RAM, some multifunction circuits, and the fixed-disk adapter). Diskettes used to get very warm to the touch after just a few minutes in either floppy disk drive, even before the fixed disk was installed. With the new power supply in place, everything stays at nearly room temperature. The only penalty is a bit of extra fan noise—comparable to the noise pro-



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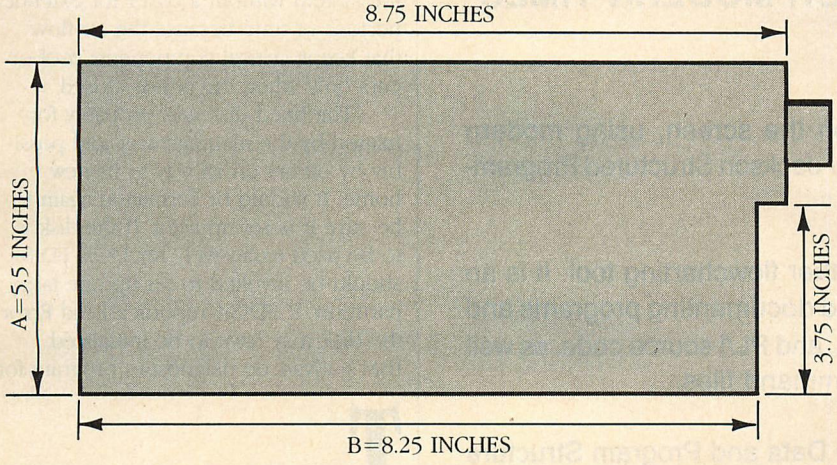
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FIGURE 1: *130-watt Power Supply Specifications*

INPUT	Voltage	110 nominal Vac (90 min, 137 max)
	Frequency	47 to 63 Hz
	Current	4.1 A max at 90 Vac
DC OUTPUTS	5.0 volts (+5%, −4%) @ 15 A (2.3 min)	
	−5.0 volts (+10%, −8%) @ 0.3 A	
	12.0 volts (+5%, −4%) @ 4.2 A (0.4 min)	
	−12.0 volts (+10%, −8%) @ 0.25 A	
AC OUTPUT	120 volts nom. (88 min, 137 max) @ 1.0 A	
PROTECTION	Power-good signal turn-on delay > 100 ms and < 500 ms	
	Power-good signal is reset after the supply is turned off for at least 1 second	
	Sense levels for protective power shutdown:	
	Nominal	Minimum / Maximum
	+5	+4.5 / +5.5
	−5	−4.3 / −5.5
	+12	+10.8 / +13.2
	−12	−10.2 / −13.2

DIMENSIONS OF THE IBM PC AND XT POWER SUPPLIES
(VIEWED FROM TOP)



Maximum height (C)=5 inches (including mounting hardware)

The 130-watt replacement power supply must meet these minimum specifications and be approximately the same size as the 63.5-watt unit that is in the PC.

duced by an XT. The power supply has excellent surge capacity. It easily handles the high starting current drawn by a refurbished MiniScribe Model 1012 disk (new electronics), which is a predecessor to the Model 2012 that was selected by IBM for the XT. The 2012 draws about half the starting current as the now discontinued 1012.

A less expensive power supply unit that is an exact physical replacement for the PC's supply is available from FORTRON. The unit has a surge capacity that is adequate to handle the start-up load of the fixed-disk motor. Both the MDI and the FORTRON power supplies provide a switched AC socket for the monochrome monitor.

The installation of the fixed-disk adapter is described in the booklet that accompanies it. The instructions should be referred to during the conversion. The hardest part of the procedure is installing the cables so that they won't be stretched or crimped, and to avoid physical interference to any other components.

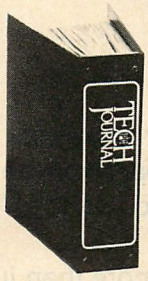
No special switch settings are needed with this modification, but the switches should be set before all the cables are installed, because the components get a bit crowded right over the switches and behind the floppy disk drive(s) — especially when two half-height units are installed. The MDI power supply is larger than the original PC supply, so it overhangs the PC motherboard, making it difficult to reach SW2, the DIP switch that is used to set the maximum memory size.

SW1 must be set to indicate how many floppy disk drives are installed.

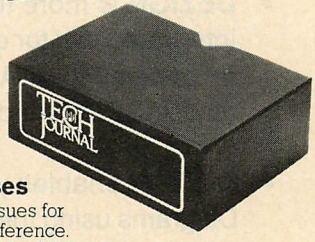
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The BIOS ROM scan function will detect how many fixed disks are installed. Fixed-disk drives should not be included in the count shown by SW1.

The wiring and cabling activity must be done carefully to assure that no damage occurs to any components and cables. Figure 3 depicts the recommended component layout and cable routing to use. The ROM BIOS upgrade should be installed before any adapter cards and cables are put in place. The ribbon cables for two fixed disks are provided with the IBM fixed-disk adapter. The connectors on the IBM cables are keyed so that they can be installed only one way, eliminating one potential source of trouble. If two fixed disks are being installed, drive C: plugs into the intermediate connector, and drive D: is on the far end of the cable from the adapter, although it is physically closer to the adapter. The terminating resistor dual in-line package (DIP) should be removed from drive C:— only the last drive in a chain should have the terminator installed to avoid reflections on the signal leads that could produce data and control errors.

A Y connector may be needed for systems that have two floppy disk drives installed internally, depending on which power supply is installed. Only two disk power cables are provided on the MDI supply. One feeds the fixed disk and the other must be split to feed the two floppies. Most disk suppliers can provide a Y connector for powering two half-height drives from a single supply connector. The FORTRON power supply provides four power cables, so the Y connector is not needed.

The next step is to verify that all cables are correctly installed and firmly connected. A smoke test will reveal whether anything gets charred when the power is first turned on. If the operation is proceeding smoothly at this point, the system unit cover may be put back in place. It is not wise to operate the system without a cover for extended periods of time because the air flow that keeps critical components cool occurs only when the unit is closed.

The fixed disk was probably formatted by the manufacturer and possibly by others on its way to its new home. It should be formatted again to be sure it is set up right. If the disk is to be used exclusively for DOS, FDISK should be invoked to set up one large partition. If FDISK reports a Read Error, the disk may have to be initialized. IBM's advanced diagnostics program for the XT (at a cost of $295) has an initialization function. Listing 1 shows (at no cost) another method. FDINIT.BAS is a BASIC program that communicates with the disk adapter through two system ports. I/O addresses 320 to 323 are read/write ports on the IBM fixed-disk adapter. Port 322 is used to generate a controller-select pulse. Port 320 is then used to write data and commands to the adapter. The (Bx) in the comments indicates the byte positions in the command sequence to the controller. The program will run in an instant, but the disk will spin for a minute or two while it is being initialized. The disk should stop running before partitioning and formatting are continued.

The connectors on the IBM cables are keyed so that they can be installed only one way, eliminating one potential source of trouble.

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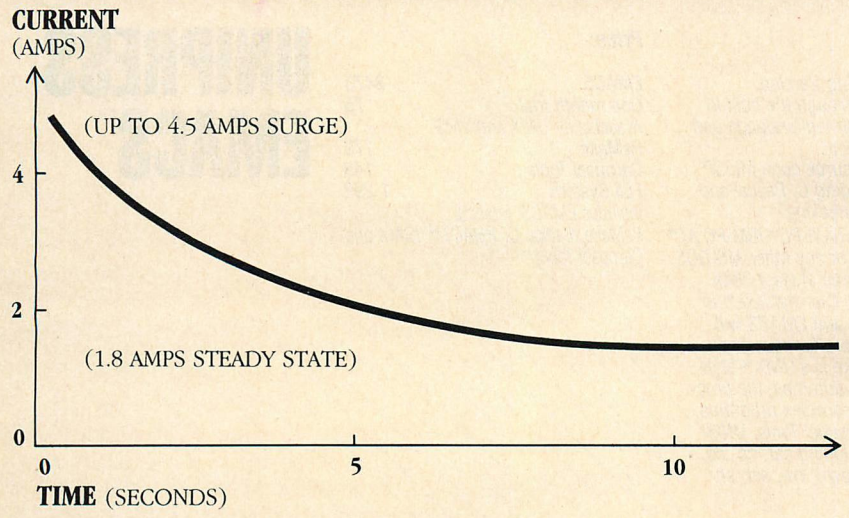
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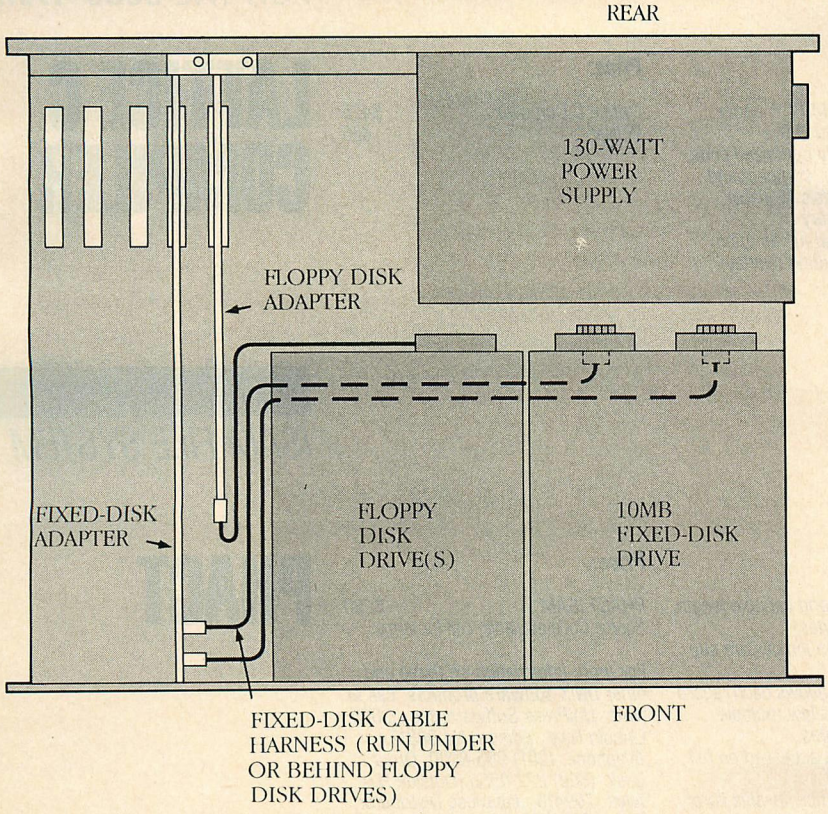
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FIGURE 2: *Motor Current vs. Time*



The fixed-disk drive may draw four or more amperes, leaving little power for other components. It settles down to a little less than two amps at steady state (3600 RPM).

FIGURE 3: *Component Layout and Cable Routing*



The recommended component layout and cable routing is depicted here. Wiring and cabling should be done carefully so that no damage occurs to any components or cables.

After a DOS partition has been set up, the FORMAT command will make the space usable by PC-DOS. FORMAT will report any errors found, such as bad sectors, but the information is not entirely dependable. FORMAT is not always accurate in marking and reporting bad sectors. Such conditions may not be discovered until DOS tries to write data into a bad sector.

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tem may need to be installed first, then set up with a DOS partition. A program that does the job of FDISK is usually provided with the operating system. Initially, I found that having about one-third of the disk—100 of the available 305 cylinders—devoted to PC-DOS and two-thirds to PC/IX suited my needs well. After about a month, however, I had filled the DOS partition with my program development and test programs, so I added a second 10MB disk, mounted externally. Then I set up one disk for PC-DOS and the other for testing various versions of UNIX and UNIX-like operating systems. External mounting required customized cables because the IBM cables are designed for two disks inside a single enclosure.

The acid test is to install PC/IX, because it checks to see that it is running on native IBM hardware. PC/IX runs on the system modified as described in this article, but fails to run with all other configurations of internal and external fixed-disk systems I tried, except the new Xebec adapter. Several other UNIX implementations were installed and ran correctly on my homemade XT and on most of the non-IBM hardware tested, because their designs make no assumptions about the brand of host hardware.

OTHER FIXED DISKS

Disks of greater (or lesser) capacity may be installed in the modified system at a cost of reduced compatibility with the PC/XT. The fixed-disk BIOS on the IBM adapter contains a table of values of fixed disks, 00 through 03. The familiar 10MB unit is identified as type 03. Types 00, 01, and 02 have capacities of 5, 26, and 15MB, respectively. Switches on the fixed-disk adapter may be set to select any of the supported types. In addition, Interrupt 41 may be used to call a parameter table placed in memory to describe other types. Early vintage IBM adapters had a DIP switch that was installed for drive type selection. Later production versions do not have such a switch because disk type 03, the default, is selected by setting all switch positions OFF, or open, which can be achieved at zero cost simply by leaving the switch off the board.

Type 01 is especially enticing. XENIX can work with fixed-disk partitions of up to 16MB, and it does not make a fuss about not running on a purebred PC/XT. PC-DOS can run in the remaining 10MB.

Augie Hansen owns Omniware, a software development and training company that is based in Denver. He is a contributing editor to this magazine.

LISTING 1: FDINIT.BAS

```
10  ' ------------------------------------------------------------
20  ' WARNING: This fixed disk initialization program will destroy
30  ' all existing data on the target drive, so anything that is of
40  ' value should be saved before this program is run.
50  ' ------------------------------------------------------------
60  '
70  OUT &H322, &H1       ' get adapter's attention
80  OUT &H320, &H4       ' (B0) class = 0; opcode = fmt drv
90  OUT &H320, &H0       ' (B1) drive 0 (c:), head 0
100                      ' [use &H20 for drive 1 (d:)]
110 OUT &H320, &H0       ' (B2 & B3) start @ cylinder 0,
120 OUT &H320, &H0       '  sector 0 and format entire disk
130 OUT &H320, &H6       ' (B4) interleave factor = 6
140 OUT &H320, &H0       ' (B5) reread on ECC, default type
150 END
```


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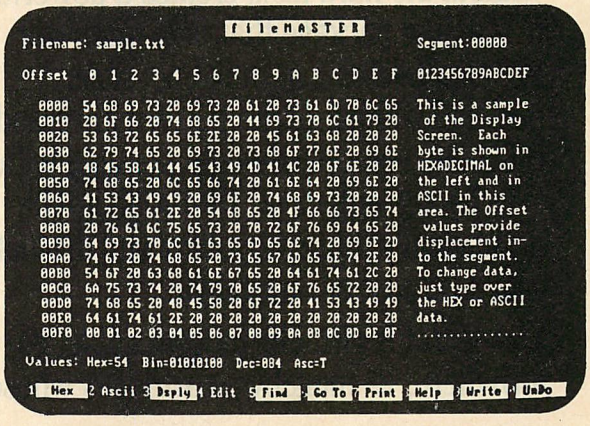
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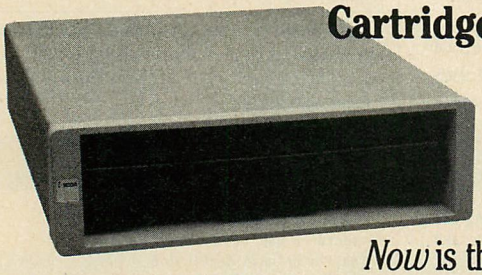
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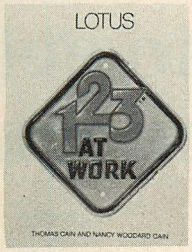
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Using 1-2-3

Two good books on Lotus 1-2-3: one that presents several useful applications and one that teaches readers how to use the system.

1-2-3 at Work
Thomas Cain and Nancy Woodward Cain (Reston Publishing Company, Reston, VA 1984) 355 pages, paper, $16.95



1-2-3 at Work is one of several books currently on the market that attempt to teach the reader how to operate the Lotus 1-2-3 program. Its authors are daily users of 1-2-3, and by virtue of this frequent use they have become eminently qualified to write about their subject. Small, topical sections of information about using 1-2-3 are interspersed with frequent examples that make the topics easy to understand.

The book, which has 14 chapters, is divided into four major parts. Part I—"Preliminary Considerations"—has two introductory chapters that describe the program, its uses, and its system requirements. The advantages of 1-2-3 over other spreadsheet software are pointed out, and examples show how its flexibility makes it nearly ideal in the corporate environment.

Part II—"1-2-3's Fundamental Commands"—consists of four chapters that slowly and methodically lead the reader through the process of entering data, in several forms, into the worksheet. Creating formats, determining column widths, choosing titles, editing the worksheet, and protecting the data are all covered here. The process of printing the output of the worksheet is described in detail; examples of print specifications are also provided.

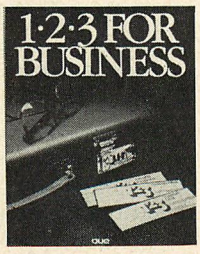
Part III—"Utilizing the Full Potential of 1-2-3"—covers the meat of using the program. Its six chapters comprise one-half of the entire book. The details of formulas and functions are explained thoroughly, with examples provided for most of the less common functions. 1-2-3's graphing features are covered in detail, including a discussion of how to create graphs and how to print them and a comparison of the various types of graphs that can be created. These chapters (including 50 pages on macros) are not overwhelming. The Cains seem to have the knack for making technical topics interesting.

The last part of the book (part IV, "Introducing 1-2-3 Applications to the User") concentrates on planning and designing efficient applications. Emphasis is placed on designing each application so that the user does not have to be knowledgeable or even particularly careful when using the worksheet.

This book ranks with the best of the 1-2-3 "how-to" books. It very ably covers nearly everything the reader could want to know about Lotus 1-2-3.

—BRUCE T. FILBECK

1-2-3 for Business
Douglas Ford Cobb and Leith Anderson (Que Corporation, Indianapolis, IN) 338 pages, paper, $14.95; optional software diskette, $79.90



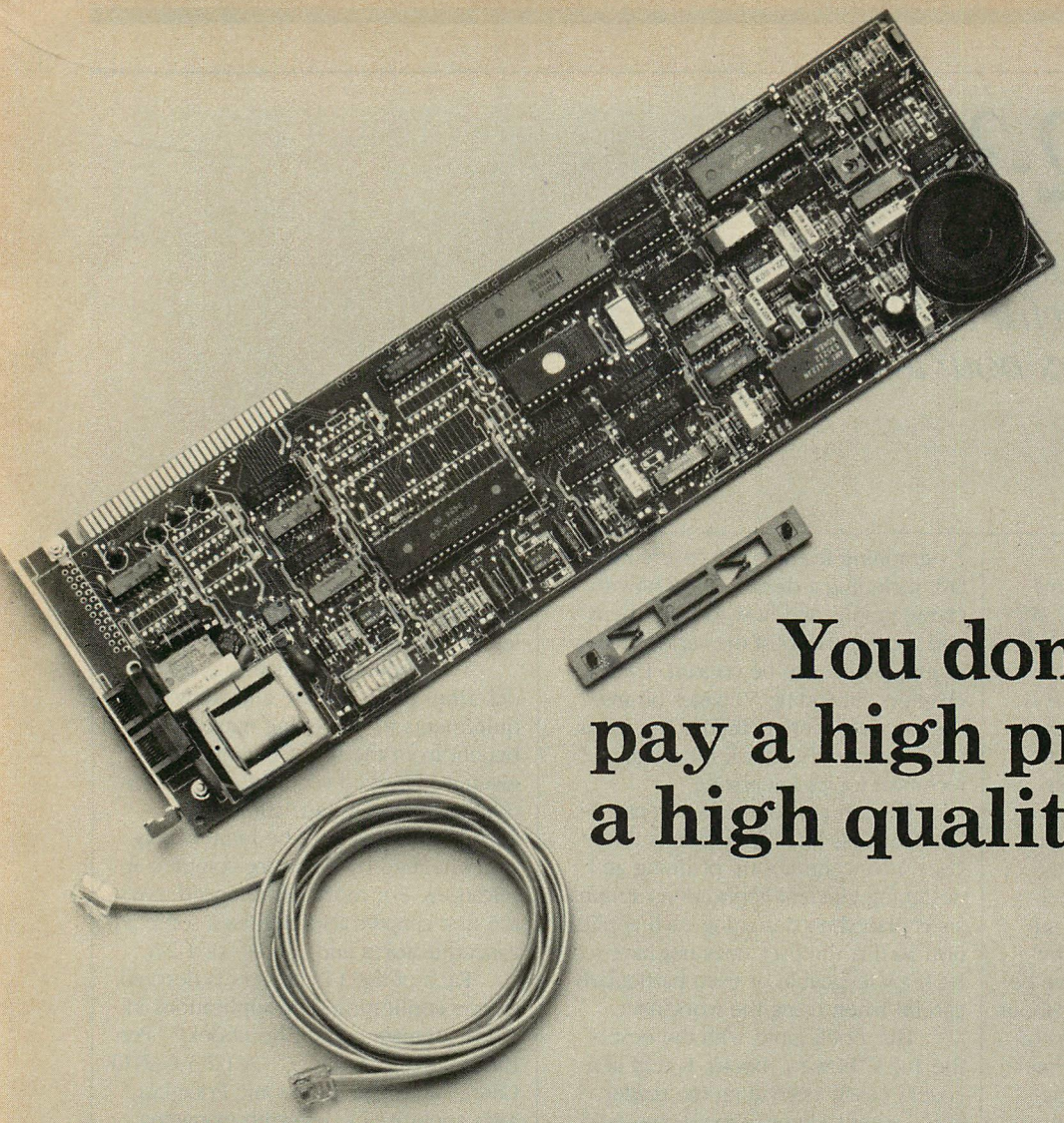
1-2-3 for Business provides the reader with several useful applications of the Lotus 1-2-3 program. The primary purpose of the book is to give the user several applications or templates that can be used in his business. Some applications are also useful in the home. Also given are excellent examples of applications that the newcomer to 1-2-3 can use to strengthen his understanding of the program. In addition, the book effectively spurs the reader into using his imagination to develop applications tailored specifically to his needs. A complete listing of each template is provided so that the user can enter it for use with the 1-2-3 program. In addition, the applications are available on a diskette, so typing can be avoided.

The book's introductory chapter describes the hardware and software requirements for obtaining maximum benefit from the book. Beginners are given a suggested sequence of applications so that they can "come up to speed" easily and not be immediately overwhelmed by the more complex applications. For more experienced users, the first chapter also mentions some advanced features and "tricks" of 1-2-3.

Each of the 14 chapters is devoted to one application. The applications include "Managing the Checkbook," "Performing Ratio Analysis," "A 1-2-3 GANTT Chart," and "The Electronic Price List." Two applications deal with managing and projecting cash flow. Tracking a line of credit, amortizing a loan, and lease-versus-debt financing are covered.

In the chapters devoted to these applications, a discussion of the topic of the application and each of its sections is provided, as well as a listing of the contents of each of the 1-2-3 cells. For example, the chapter entitled "Amortizing a Loan" begins with several paragraphs describing the principles of loan amortization; next, each of the application's five sections—Assumptions, Amortization Table, Criterion Range, Statistics Range, and Output Range—is discussed. A section called "Using the Model" follows. It describes how to adjust the interest rate or the principal payment and how to use the criterion, statistics, and output ranges. The chapter ends with a short paragraph that mentions some of the highlights of the model, such as its unusual use of the @CHOOSE function. A figure showing the output of the model is provided, and the contents of each cell are listed so that the model may be entered into the computer.

1-2-3 for Business is well-written and provides useful applications. For



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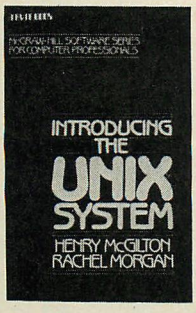
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users who need any of the applications or who just want to see examples of some of 1-2-3's more complex functions, this book is a good choice.

—BRUCE T. FILBECK

Introducing the UNIX System
Henry McGilton and Rachel Morgan
(McGraw-Hill Book Company, 1983)
556 pages, $18.95



The UNIX system is large by microcomputer standards. An introduction to the topic that consumes well over 500 pages is indicative of the size and complexity of this increasingly popular operating system. McGilton and Morgan cover Version 7 UNIX (AT&T Seventh Edition) and derivatives produced at the University of California at Berkeley. The book was designed to be a companion to existing UNIX documentation rather than a replacement.

Up front is a short chronology of UNIX development—one that spares the reader the usual blend of fact and fiction concocted by some UNIX authors—and a concise summary of the major UNIX components and attributes. The detailed coverage begins, as it must, with information on how to get started using UNIX, followed by a discussion of files and directories, then commands and standard files. The first four chapters thus give the novice UNIX user a good working knowledge of the essential elements of the operating system and its user interface.

Chapter 5 delves into communications between and among users. The next five chapters, roughly half of the book, deal with various aspects of creating and manipulating text, a testimonial to one of the important uses of UNIX. The authors have concentrated on the essential 20 percent that shows users how to do the majority of their writing tasks on UNIX.

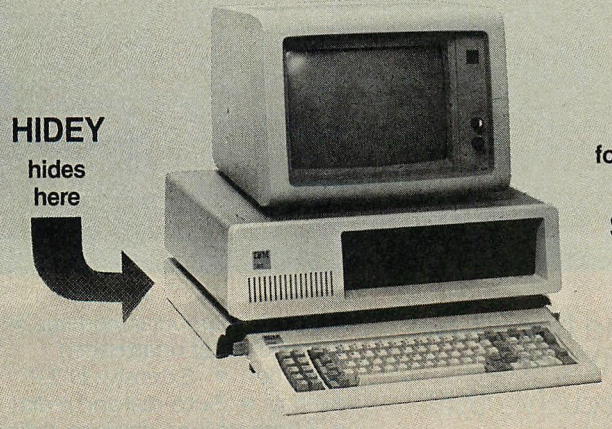
Chapter 11 gives a cursory introduction to programming in the UNIX Shell. The Bourne Shell (**sh**) is described and used for all examples. The C-Shell (**csh**), developed at Berkeley, is only alluded to in this chapter. Its salient features and those of other Berkeley variations are summarized in chapter 13. Chapter 12 describes software development tools. Although readers will not learn to program UNIX in this chapter, they will gain insight into the tools provided with UNIX for creating (**cc** and **ld**), testing (**lint**, **time**, **size**, etc.), and maintaining (**ar**) software. There is no mention of the source code control system (SCCS) in this book because that facility was not a part of the seventh edition.

The last chapter is for those who must set up and maintain UNIX systems. The material is generalized enough to be a useful adjunct to the documentation provided with UNIX, but it cannot stand alone because of system variations. It is particularly valuable for users who will be installing UNIX-derivatives like PC/IX and Venix/86 on PCs.

Introducing the UNIX System is the book I prefer to use in classroom instruction for beginning UNIX users. The coverage is even and well organized and takes the reader from first log-in through the basics of system administration. If I could keep but one of the dozen or so books on UNIX in my library, this is the one I would choose.

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The Tort of Copy Protection

Deliberate-damage copy protection schemes are risky business.

Imagine that you have been cheated by automotive repair shops *repeatedly.* (Please bear with me—I assure you this is *PC Tech Journal* and not a copy of *Car and Driver* bound with the wrong cover). Your car is again in need of repair, and you drive to a dealer—not one who has cheated you before (after all, you are not stupid).

Determined not to be cheated again, you pay by a special check that has printed on its face, along with all the normal electronic coding, an additional code that will zero out the balance of the account to which it is deposited unless a second code is entered within a few days. If the repair is satisfactory, you plan to cause the second code to be entered and all will be well. If the repair is not, then the shop will get what it deserves. Unfortunately, everyone whom the shop pays by check will suffer as well, but that is the price they must pay for dealing with a crook. The possibility also exists that the second code will not be entered as planned or will not work as planned, but that, too, is the price that honest mechanics must pay for being in an industry that is not entirely honest. When your code wipes out the bank account, you will have (imaginarily) committed, among other things, a tort.

A tort is a civil (as opposed to criminal) wrong that causes injury. The injury can be physical injury to a person (as in battery), emotional injury (as in slander), or injury to property (as in trespass). Torts can also be divided into the broad categories of negligent torts and intentional torts. The distinction matters because negligent torts are generally compensable by awarding the injured party damages equal to the injury suffered, while intentional torts may give rise to so-called "punitive damages" designed to teach the tortfeasor (the party who committed the tort) a lesson and to send a message to others of his ilk. The legal concept of what is compensable as a tort has been expanding as new types of property interests and injury have been recognized.

To my knowledge, no case has yet held that the use of a copy-protection scheme that inhibits copying is a tort, although the argument might be made that if a shrink-wrap license (see "Shrink-wrapped Magazines," February 1984, p. 169) is invalid, then preventing a purchaser from storing his copy of a program on a hard disk lessens the value of his copy. Whether that would fall within the definition of trespass or would require the creation of a new class of tort based on interference with rights granted by the copyright law is a matter of speculation.

However, reports are out about a new type of copy protection that fits more easily into traditional tort law: a program designed deliberately to damage portions of the user's system if the program does not verify the presence of an original disk.

I would caution against the use of such a protection scheme simply because an industry trying desperately to be user-friendly can ill afford to adopt measures designed to do deliberate violence to users. For those not satisfied with this emotional reason, I have prepared a dispassionate, economic argument against the use of such systems.

A simple mathematical exercise will establish the outer limits of the usefulness of a deliberate-damage protection scheme. The benefits equal the number of sales lost to piracy (which is unlikely to be the same as the number of pirated copies) multiplied by the publisher's profit per sale. The costs equal the price of the protection process, plus the number of sales lost because some users refuse to buy a program protected in this fashion multiplied by the profit per sale, plus the expected number of malfunctions multiplied by the average damage per malfunction (which assumes that all injured users actually collect the amount of their injury).

If the simplifying assumptions are made that the cost of the protection process is insignificant and that the risk of malfunction per disk produced is a constant regardless of production rate, and if we relate the costs and benefits to existing sales, we have the following equations to compare:

BENEFITS (PER CURRENT SALE): PIRACY LOSSES/CURRENT SALE ("%PIRL") * PROFIT/SALE ("PROF")

COSTS (PER CURRENT SALE): FRACTION OF CURRENT PURCHASERS WHO WON'T BUY DELIBERATE-DAMAGE SOFTWARE ("%DDL") * PROFIT/SALE + RATE OF MALFUNCTION/DISK ("%ERR") * (CURRENT SALES + PIRACY LOSSES—PROTECTION OBJECTION LOSSES) * AVERAGE DAMAGE PER MALFUNCTION ("AVDM")

The protection system makes economic sense if, but only if,

%PIRL * PROF > %DDL * PROF + %ERR * (CURRENT SALES + %PIRL − %DDL) * AVDM

The best-case assumptions would be that losses due to objecting consumers will be insignificant and that piracy losses (%PIRL) are much greater than current sales. Under these assumptions, the equation approaches:

%PIRL * PROF > %ERR * %PIRL * AVDM

or:

PROF > %ERR * AVDM

In other words, the protection mechanism is economically sensible when the profit per sale exceeds the rate of error in the protection system multiplied by the average damage cost per error (and where, as was assumed above, the rate of piracy far exceeds the rate of sales).

What this equation suggests is that such protection schemes may be suitable for low-risk-of-damage, high-risk-of-piracy software. Presumably, games would fall into this category (although

there would be the risk of destroying the tax records Mom and Dad stored on the hard disk when one of Junior's friends tried to run a pirated game). Paradoxically, the more valuable the software, the greater the risk of the protection scheme. Similarly, the more often the software is used, the more likely a medium-related malfunction and, therefore, the higher the risk.

To evaluate the economics more precisely, the parties need numbers for the variables. Probability and quality control determine the risk of malfunction. Tort law principles determine how damages are computed and who pays.

A hypothetical example may help explain the problem. FriendlyLock produces a system that demands the presence of an original disk and destroys the contents of the user's entire disk (a hard disk, if one is present) if it doesn't find one; CuddlyWare protects its programs using the FriendlyLock system; ConsultingSoft packages CuddlyWare with hardware and then sells it.

I will examine the easy case first—in which the protection system malfunctions, damaging the property of the owner of an authorized copy of the CuddlyWare software.

The case against ConsultingSoft would likely turn on three issues: the standard of care required of computer consultants; whether ConsultingSoft knew or should have known of the potential for malfunction and resulting damage; and whether ConsultingSoft had adequately warned the user of the risk and explored the possibility of using a software package that did not have the FriendlyLock feature.

There is an emerging view of computer consultants as experts to be held to similar malpractice standards as doctors, lawyers, and accountants. If held to that standard, ConsultingSoft would be hard pressed to argue successfully that it had no reason to anticipate the possibility of an error occurring with the resultant damage (unless CuddlyWare kept its use of FriendlyLock a secret, which would seem counterproductive). If alternative programs were available, it might be very difficult to persuade a court that a sentient user had been "adequately" warned and still decided to gamble his business on the continued proper functioning of a floppy disk.

ConsultingSoft has reason for concern. On the bright side, Consulting Soft's liability would probably be viewed as arising from negligence and therefore limited to the actual damages suffered by the user. These damages could, of course, be substantial if the user's business depended heavily on proper operation of its computer.

One would expect the case against CuddlyWare to be even stronger since it made the decision to employ the mechanism that caused the damage. It is likely that these defenses would be urged:

1. The fault is with the design of the protection scheme; the blame should be placed on FriendlyLock.
2. The user assumed the risk since the license agreement that was packed with the program said, "The user assumes all risks. . . " and "This program is not guaranteed to function properly or without error."
3. CuddlyWare did nothing more than take reasonable steps to protect its property—it was self-defense.

Given the choice, I would rather be representing the injured user, not out of sympathy, but out of a preference for winning. While the first defense might enable CuddlySoft to sue FriendlyLock, it is not likely to help it against the user. A publisher who

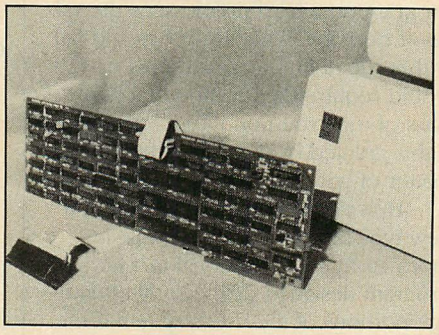
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adopts such a protection mechanism should be aware that it, like any program, might malfunction. Likewise, anyone dealing with disk software should know that, with use, disks are liable to suffer from errors. (Perhaps publishers using such schemes should require maintenance every six months or 6,000 miles, whichever comes first.)

As for defense number two, the validity of shrink-wrapped agreements is open to question in general and is all the more vulnerable when the assumption of risk language is so vague. I would question whether the normal all-risk-is-with-the-buyer language would be held to protect the perpetrator of deliberately induced malfunctions.

If the license agreement has been individually negotiated, a court is more likely to enforce a provision shifting the risk to the user. However, the user is

On the bright side, ConsultingSoft's liability would probably be viewed as arising from negligence.

also more likely to insist on deleting such a provision. In fact, unless the program is unique and the user is desperate, he will likely insist on precisely the opposite sort of provision in the contract, such as:

> "Vendor represents and warrants that the software contains no elements deliberately designed to cause erroneous results, damage to the software or to other programs or data, damage to the user's hardware or other malfunction, under any circumstances whatsoever. Vendor's limitation of liability (if one is contained in the contract) shall not apply to damages caused by any such elements, and vendor shall be liable to user for all damages caused by the existence of such elements, including but not limited to incidental and consequential damages, lost profits, and unrealized savings."

Even if CuddlyWare prevails in its exculpation-by-license-provision defense, it faces a similar risk, not from the user, but from the government. Several states have enacted or are considering statutes similar to a Maryland law that makes it a misdemeanor to "intentionally . . . and without authorization access . . . a computer system . . . or any part of these systems." The law was aimed at hackers, but could not the argument be made that CuddlySoft had, through its program, accessed the user's data (and caused damage)? To infer that the user had authorized such access would be difficult. Thus, such anti-hacker statutes might apply both to CuddlySoft and the other parties. Whether or not a valid license agreement could be drafted to insulate CuddlySoft from tort liability, a victim cannot waive the government's right to prosecute a crime.

The self-defense argument has two flaws: traditionally, self-defense is a criminal law concept, and even in that context requires that the defender attack the attacker, not some innocent bystander, and further requires that the defensive efforts be reasonable in light of the threat. Assuming that the efforts would be viewed as reasonable, CuddlyWare still has a problem, because the

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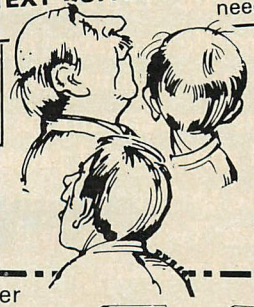
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user is innocent of any wrongdoing. CuddlyWare's activities could be viewed as an intentional tort, which would permit the recovery not only of damages for the user's actual injury, but also of punitive damages. The trier of fact (the jury or, in a nonjury trial, the judge) has substantial latitude in determining the amount of punitive damages.

If CuddlyWare's exposure is greater than ConsultingSoft's, one might expect that FriendlyLock's exposure would be greater still. This would be so if CuddlyWare's contract with FriendlyLock provides that FriendlyLock will indemnify CuddlyWare against liability, but the user has a more complicated case against FriendlyLock than he does against CuddlyWare. What defense might FriendlyLock use? Ironically, FriendlyLock might find itself depending on the same legal argument that publishers of nibble copiers do: the product can serve a legitimate function; whether it does or not depends at least in part on how it is used.

FriendlyLock's fundamental argument would likely be that it had simply provided CuddlyWare with a tool. How that tool was used or abused was beyond FriendlyLock's control and responsibility. ("FriendlyLocks don't kill data; users kill data.") In most states, the introduction of an inherently dangerous product into commerce imposes "strict liability" on the manufacturer; that is, an injured user need not show that the injury was intentionally caused by the manufacturer, only that the manufacturer knew of the inherent danger and failed to take adequate steps to protect or warn the user. Even if FriendlyLock prevailed against the user's direct suit, it would, as noted above, have to contend with the indirect claim that would arise if a user prevailed against CuddlyWare, which then sued FriendlyLock. The outcome of that claim might turn on the terms of the FriendlyLock-CuddlyWare contract. FriendlyLock would likely ask CuddlyWare to assume the risk of malfunction and vice versa.

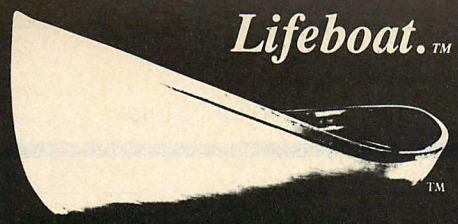
No direct precedent exists to answer the question of who is ultimately liable for user injuries caused by malfunction of a deliberate-damage protection scheme. Each of the parties is certainly at risk. Does the risk disappear if the protection scheme functions properly and only destroys data when an unauthorized copy is used? What about the issue of whether reasonable force was used in self-defense? The question of whether the self-defense was misdirected can arise as well. For example, suppose the user was unaware of the unauthorized copying. (Perhaps ConsultingSoft made the unauthorized copy and then sold the package to the user.) Thus, even if the protection scheme functions perfectly, each party would assume some risk.

There is theoretical risk even in the use of copy protection systems that respond to a putative unauthorized copy by refusing to function. I am not aware of any lawsuits arising out of the malfunction of such systems. Users probably view the nuisance of having to work from a floppy rather than a hard disk, and the occasional inconvenience of waiting for a back-up copy to arrive when the original crashes, as a reasonable price to pay to help software authors and publishers protect their rights. Users might not take the same view of the destruction of 10MB of data.

Max Stul Oppenheimer, PC, is a partner in the law firm of Venable, Baetjer & Howard, located in Baltimore.



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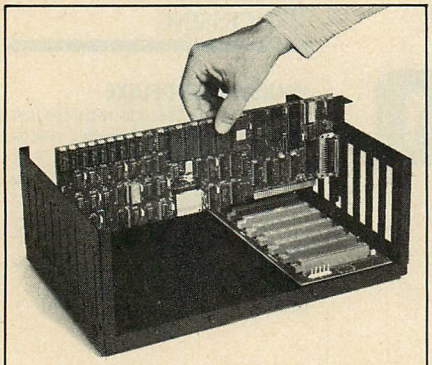
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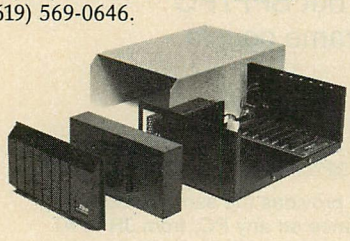


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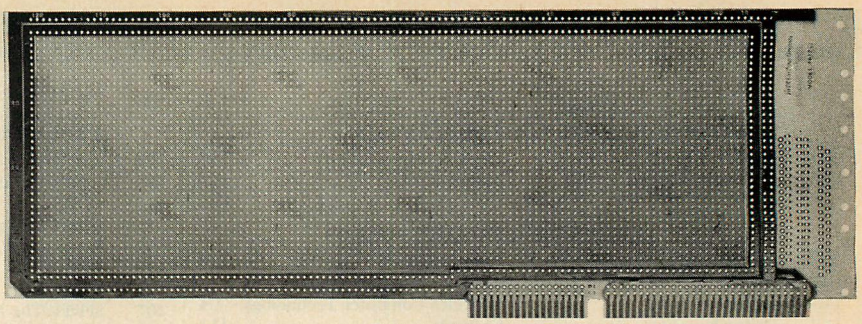
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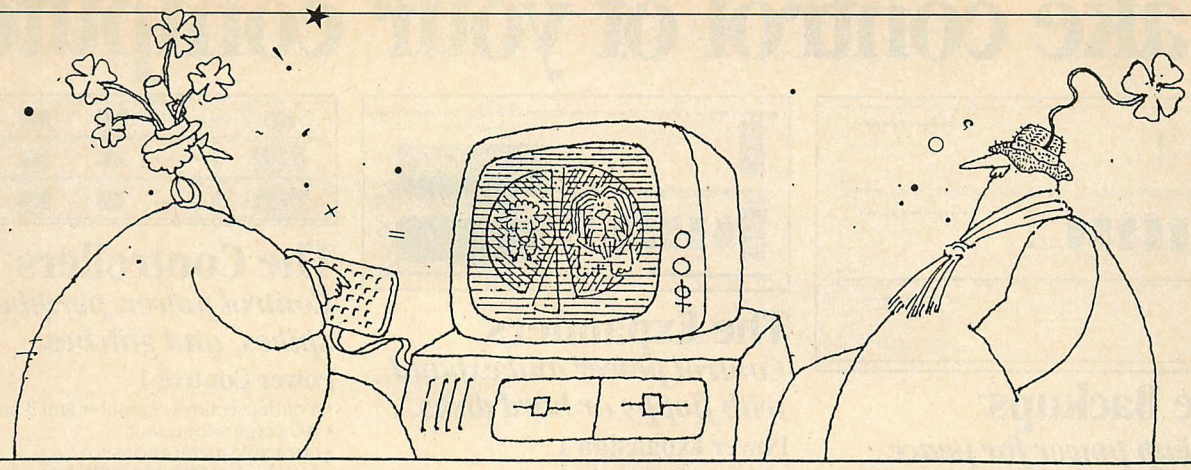


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Contact: D. Austin Henderson, Jr., Xerox PARC, 3333 Coyote Hill Road, Palo Alto, CA 94304

April 15-17
Conference on Software Tools
New York, NY
Sponsor: Polytechnic Institute of New York in cooperation with ACM and IEEE TCSE
Contact: Martin L. Shooman, Polytechnic Institute of New York, 333 Jay Street, New York, NY 11201; 212/643-5174

April 20-21
10th Annual Trenton Computer Festival
Trenton, NJ
Sponsors: Amateur Computer Group of New Jersey, et al
Contact: Department of Electronics Engineering Technology, Trenton State College, Hillwood Lakes CN 550, Trenton, NJ 08625; 609/771-2487

April 23-25
Federal DP Expo and Conference
Washington, DC
Contact: Amy Marks, The Interface Group, 617/449-6600

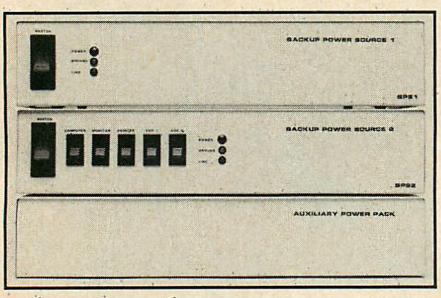
April 23-26
UNIX SYSTEMS EXPO/85
San Francisco, CA
Sponsor: Computer Faire, Inc.
Contact: Sally O'Neill, Computer Faire, Inc., 181 Wells Avenue, Suite 201, Newton, MA 02159, 800/826-2680

April 25-28
4th Annual New York Computer Show & Software Exposition
Long Island, NY
Sponsor: CompuShows, Inc.
Contact: CompuShows, Inc., P.O. Box 3315, Annapolis, MD 21403; 800/368-2066

April 25-28
4th Annual Virginia Computer Show & Software Exposition
Virginia Beach, VA
Sponsor: CompuShows, Inc.
Contact: CompuShows, Inc., P.O. Box 3315, Annapolis, MD 21403, 800/368-2066

April 30-May 2
AI and Advanced Computer Technology Conference/Exhibition
Long Beach, CA
Sponsor: Tower Conference Management Company and *Digital Design Magazine*
Contact: Tower Conference Management Company, 331 West Wesley Street, Wheaton, IL 60187; 312/668-8100

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- visual and audible power interrupt alarm
- fast automatic switching
  (Within 6 milliseconds of peak voltage detection)
- 2 Outlets
- AC surge suppressor
- 3 stage noise filter
- thermal output protection
- IEC power connector
- attractive metal enclosure
- 3¼" high, 16" wide, 11" deep

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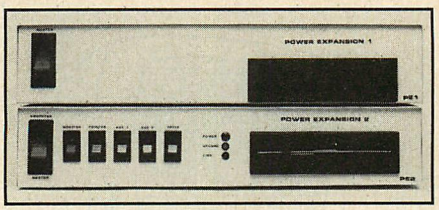
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- cross suppression between all 6 outlets
- optional 2 hour auxiliary power pack

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- cross suppression between all 6 outlets
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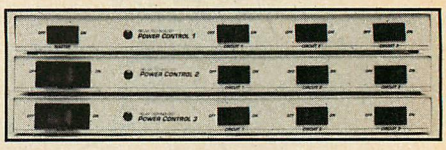
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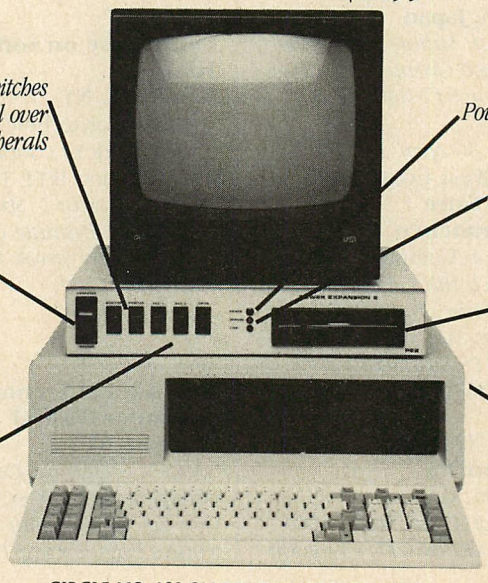
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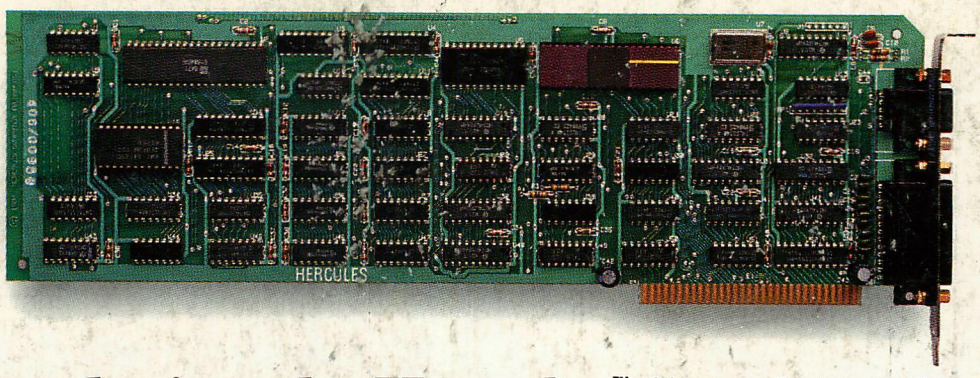
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In fact, it's exactly the same as the standard Hercules Graphics Card running programs like 1-2-3™ and Symphony™ in more than 100,000 IBM® PCs.

We just wanted to make the point that the Hercules Graphics Card is not only big with business users—it's also the most popular high resolution graphics card for the technical user.

Why? We run more software than anyone else.

The Hercules Graphics Card is supported by more technical software than any other hi-res graphics card.

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